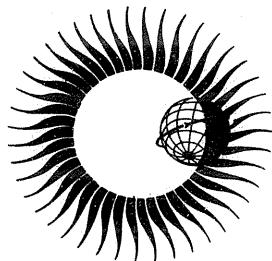


# WORLD DATA CENTER A for Solar-Terrestrial Physics



## SELECTED DISTURBED D-REGION ELECTRON DENSITY PROFILES

Their relation to the undisturbed D-region



OCTOBER 1978

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# WORLD DATA CENTER A for Solar-Terrestrial Physics



REPORT UAG-69

## SELECTED DISTURBED D-REGION ELECTRON DENSITY PROFILES

Their relation to the undisturbed D-region

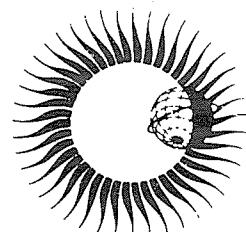
by

L.F. McNamara  
Ionospheric Prediction Service  
Sydney, Australia

OCTOBER 1978

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## TABLE OF CONTENTS

	<i>Page</i>
Abstract . . . . .	1
Method . . . . .	1
Acknowledgment . . . . .	2
OBSERVED AND MODEL D-REGION ELECTRON DENSITY PROFILES . . . . .	3
Plots During Solar Eclipse . . . . .	3
Plots During Solar X-ray Event . . . . .	6
Plots During Winter Anomaly Day . . . . .	10
Plots During Solar Proton Event . . . . .	14
Plots During Auroral Absorption Event . . . . .	25
Plots During Polar Substorm . . . . .	36
Plots During Auroral Arc . . . . .	39
APPENDIX A . . . . .	41
Program DISPPLT . . . . .	41
File PRODAT . . . . .	46
Subroutine PROFILE for magnetically disturbed days . . . . .	47
APPENDIX B . . . . .	48
Program DREGPLT . . . . .	48

SELECTED DISTURBED D-REGION ELECTRON DENSITY PROFILES  
Their relation to the undisturbed D region

by

L.F. McNamara  
Ionospheric Prediction Service  
Sydney, Australia\*

**ABSTRACT.** A large collection of experimental D-region electron density profiles has been searched to find those profiles obtained under disturbed conditions, such as eclipses and solar flares. Where possible, each disturbed profile has been associated with a suitable reference profile corresponding to the undisturbed ionosphere, in order to determine the effect of the particular kind of disturbance. A model electron density profile corresponding to the undisturbed ionosphere has also been calculated in each case, and may be used as a reference profile when no suitable experimental profile is available. All profiles have been plotted in a self-evident format which makes it easy to see the effect of the disturbance considered.

Method

This report presents a collection of observed and model D-region electron density profiles that is designed to illustrate the effects on the profiles of various kinds of phenomena. Detailed descriptions of the phenomena are not given because these are available either in standard texts or in the journal articles from which the profiles have been extracted. The main emphasis is one of illustrating the effects on the profile of the different phenomena. References are given in Part III of McNamara [1978].

All observed profiles have been extracted by computer from the D-region electron density data base established by McNamara [1978], using the "special case parameter" associated with each profile. These parameters and the associated physical phenomena are listed in Table 1.

Table 1. Phenomena Corresponding to the "Special Case" Parameter.

Parameter	Physical Description
1	Solar eclipse
2	Solar flare
3	Solar X-ray event
4	Sudden ionospheric disturbance
5	Winter anomaly day
6	Mid-latitude particle precipitation
7	Solar proton event/solar cosmic ray event
8	Polar cap absorption
9	Auroral absorption
10	Daytime absorption event
11	Polar substorm
12	Polar radio blackout
13	Auroral arc conditions

NOTE: The descriptions are those given by the individual authors and some are equivalent or have the same causal mechanism.

Each of the observed profiles has associated with it a model profile derived from all undisturbed profiles in the complete data base [McNamara, 1979]. Many of the profiles also have associated with them a reference profile corresponding to the undisturbed ionosphere and one usually observed just before or just after the event in question.

\*Guest worker at World Data Center A for Solar-Terrestrial Physics, NOAA, Boulder, Colorado.

Consideration of each of the following diagrams must include the suitability of the reference profile and the error bars associated with each of the observed, reference and model profiles, as well as the effect of the phenomena being considered. The error bars have been discussed by McNamara [1978; 1979]. A reasonable and simple estimate is  $\pm 0.5$  in  $\log_{10}N$ , or  $\pm 1/2$  division along the X axis of each diagram. This corresponds to a factor of 3 in density. Differences between profiles which are less than this value cannot be classed as "real". On some occasions, the model profile will agree better with the disturbed profile than with the undisturbed one. Under these circumstances the model profile should be ignored. Such failures of the model are only to be expected, especially when the differences between profiles are of the order of the error bar.

The first figure may be used to illustrate the presentation of the data. In general, there will be three profiles: an observed (disturbed) profile (O), a reference profile (R), and a model profile (M). In some cases, no suitable reference profile was available in the data base, so the observed profile can be compared only with the model profile. The reliability of the model profile is thus an important consideration.

Each observed or reference profile is identified by a unique three-digit curve identification number. In the first figure these are 947 and 948, respectively. These numbers are sufficient to extract the corresponding data from the computer files DB1 and DB3, which comprise part of the data base [McNamara, 1978], including the parameters listed at the top of the figure. These parameters give the relevant conditions of the experiment--the year, month, day, local time, monthly average sunspot number, latitude and longitude of the observing station, method of observation, and a magnetic index. The METH parameter may assume one of the following five values: (1) partial reflection; (2) rocket; (3) wave interaction; (4) LF-VLF reflection; and (5) other, e.g., incoherent scatter. The magnetic index MAG is 1 for magnetically quiet days (approximately  $A_p < 25$ ) and 2 for disturbed days. The parameter REF is a literature reference number, which may be used to find the corresponding journal or report reference in the computer file DB2 of the data base or in Part III of McNamara [1978]. The figure number FIG is the figure number in that reference.

The last parameter in each line is SPC, the special case parameter described in Table 1. It is zero for the reference profile. The model profile is calculated using the year, month, day, local time, sunspot number, latitude and longitude corresponding to the observed profile. The model for magnetically quiet days differs slightly from that for magnetically disturbed days. It is most likely to fail at night and at high latitudes, because the data base includes fewer undisturbed nighttime, high-latitude profiles than daytime mid- and low-latitude profiles.

The computer program DISPLLT used to prepare the data for plotting is listed in Appendix A. The actual plots were made using the software package of the Integrated Software Systems Corporation called "DISPLAA" and the program DREGPLT listed in Appendix B.

Some of the phenomena corresponding to different special case parameters have in fact the same causal mechanism. The associated plots have therefore been grouped together and described by the causal mechanism. Thus solar flare (2), solar x-ray event (3) and sudden ionospheric disturbance (4) are grouped under solar x-ray event; solar proton event (7), polar cap absorption (8) and polar radio black-out (12) are grouped under solar proton event.

Not all available plots are included, since some are very similar to each other and contain no further useful information. In some cases, consecutive plots show the time development of the event.

#### Acknowledgment

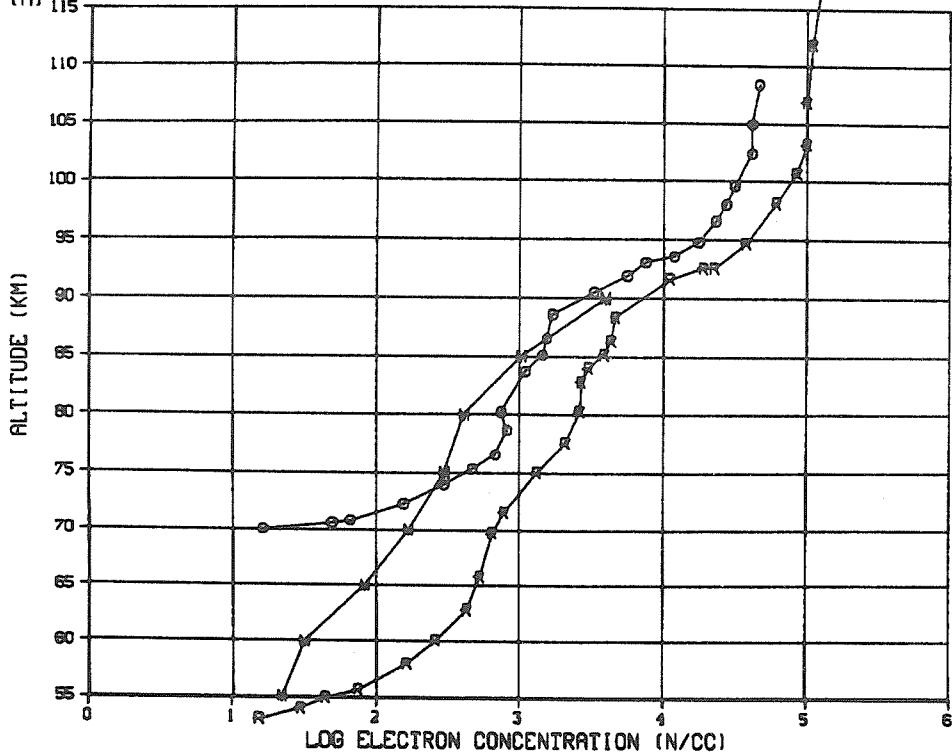
The plotting program DREGPLT was written and run by Marcus O. Ertle, NOAA/EDIS.

#### REFERENCES

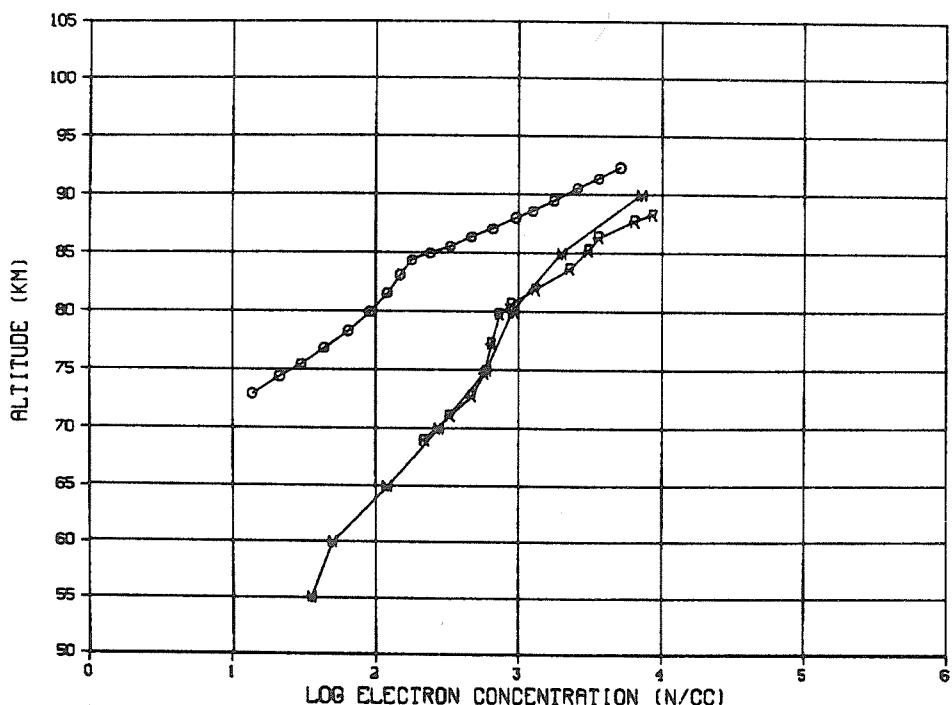
- |                |      |   |
|----------------|------|---|
| McNAMARA, L.F. | 1978 | Ionospheric D-Region Profile Data Base--A Collection of Computer-Accessible Experimental Profiles of the D and Lower E Region. Report UAG-67, World Data Center A for Solar-Terrestrial Physics, Boulder, Colorado. |
| McNAMARA, L.F. | 1979 | Statistical Model of the D-Region. Submitted to <u>Radio Science</u> .  |

OBSERVED AND MODEL D-REGION ELECTRON DENSITY PROFILES

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	947	63	7	20	1503	28	58.8	265.8	2	1	125	13	1
REFERENCE (R)	948	63	7	20	1610	28	58.8	265.8	2	1	125	13	0
MODEL (M)													

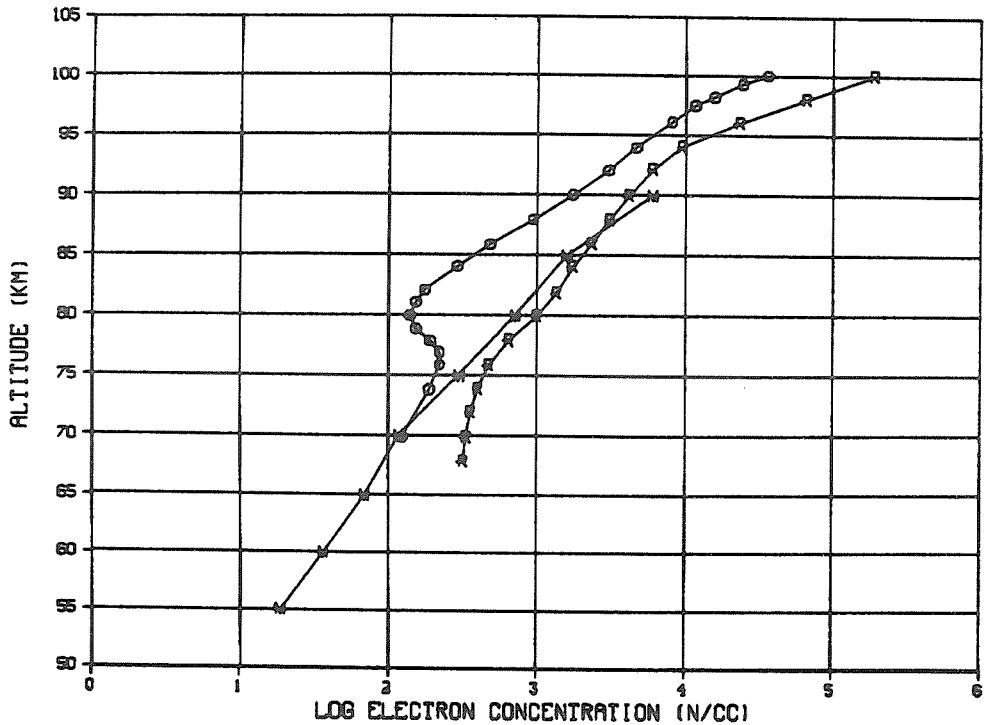


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	850	66	5	20	1045	41	36.8	21.9	2	1	78	3	1
REFERENCE (R)	234	66	5	20	1130	41	36.8	21.9	2	1	78	3	0
MODEL (M)													

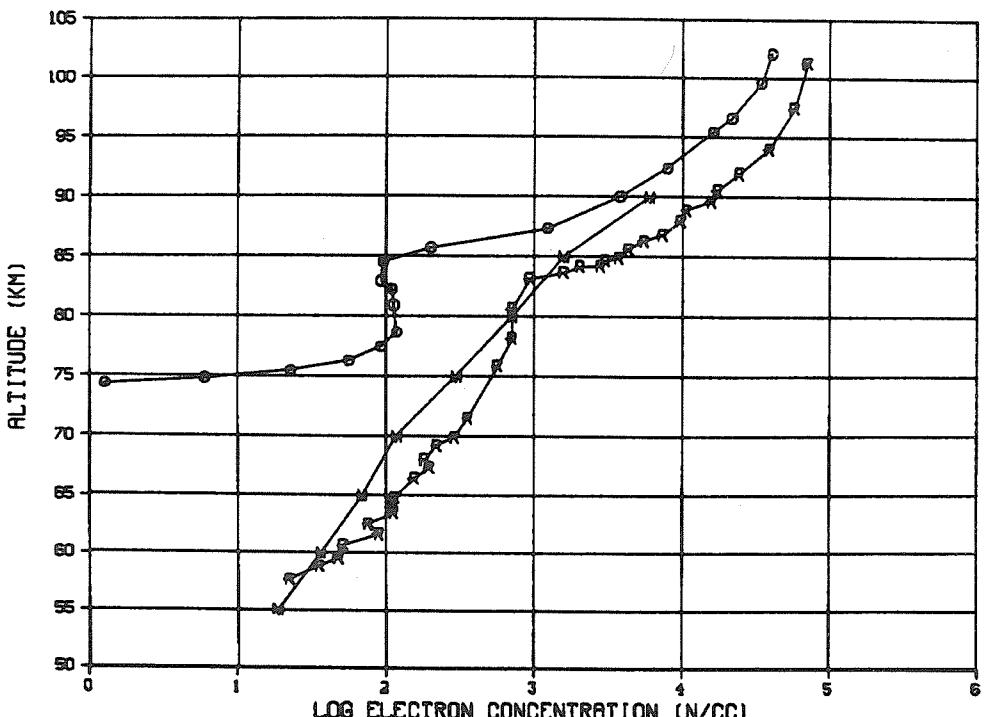


SOLAR ECLIPSE. #947 AND 850 DURING TOTALITY

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
OBSERVED (O) 809 66 11 12 1040 70 -32.0 308.0 1 1 155 17 1  
REFERENCE (R) 808 66 11 0 1045 70 -32.0 308.0 1 1 155 17 0  
MODEL (M)

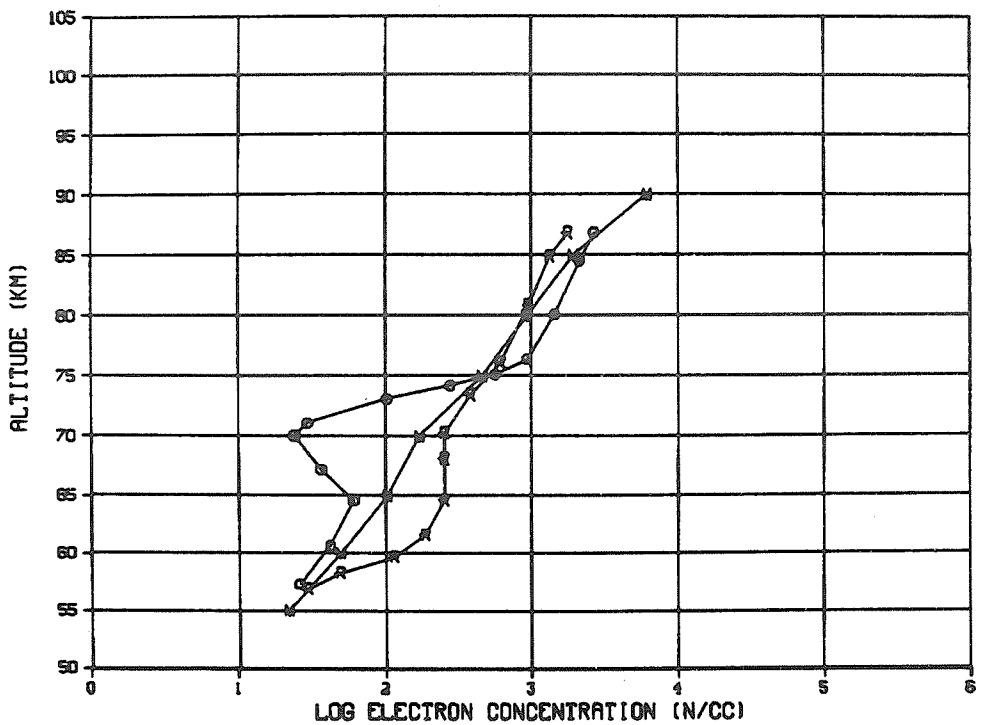


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
OBSERVED (O) 944 66 11 12 1040 70 -32.0 308.0 2 1 89 4 1  
REFERENCE (R) 943 66 11 12 1230 70 -32.0 308.0 2 1 89 4 0  
MODEL (M)

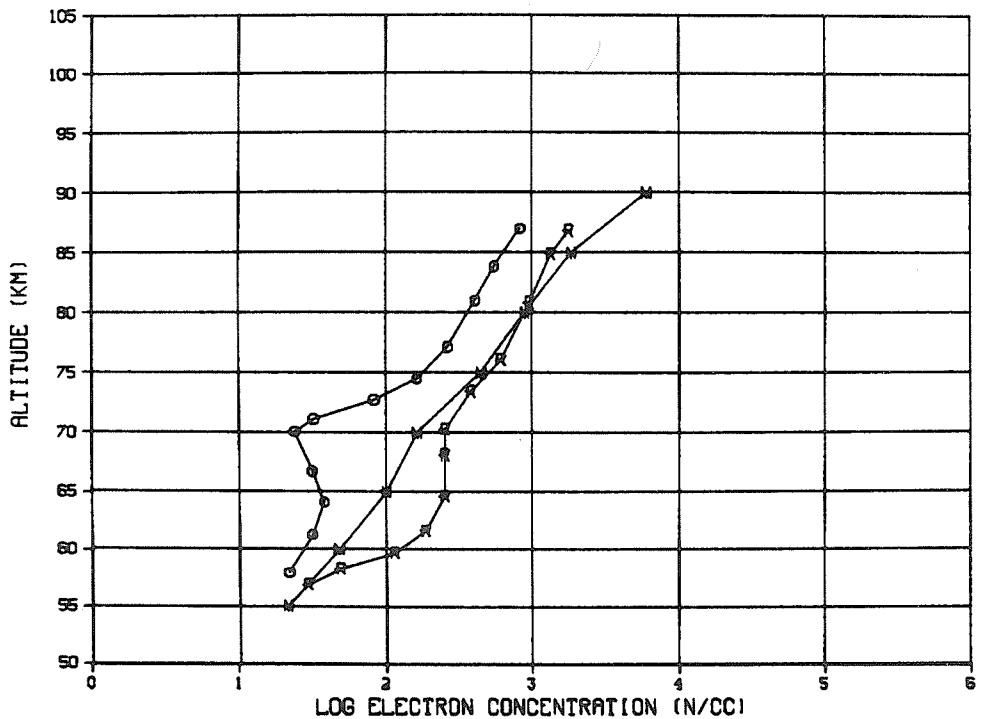


SOLAR ECLIPSE. #809 AND 944 DURING TOTALITY

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	409	70	3	7	1309	106	40.8	282.1	3	1	114	2	1
REFERENCE (R)	417	70	3	11	1310	106	40.8	282.1	3	1	114	2	0
MODEL (M)													

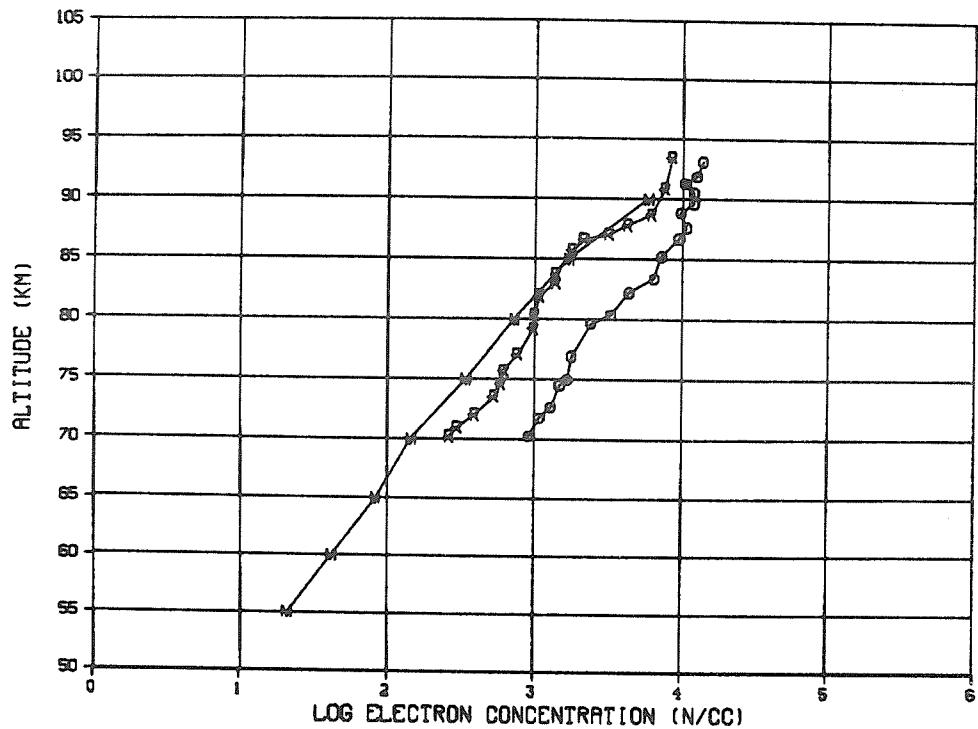


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	410	70	3	7	1328	106	40.8	282.1	3	1	114	2	1
REFERENCE (R)	417	70	3	11	1310	106	40.8	282.1	3	1	114	2	0
MODEL (M)													

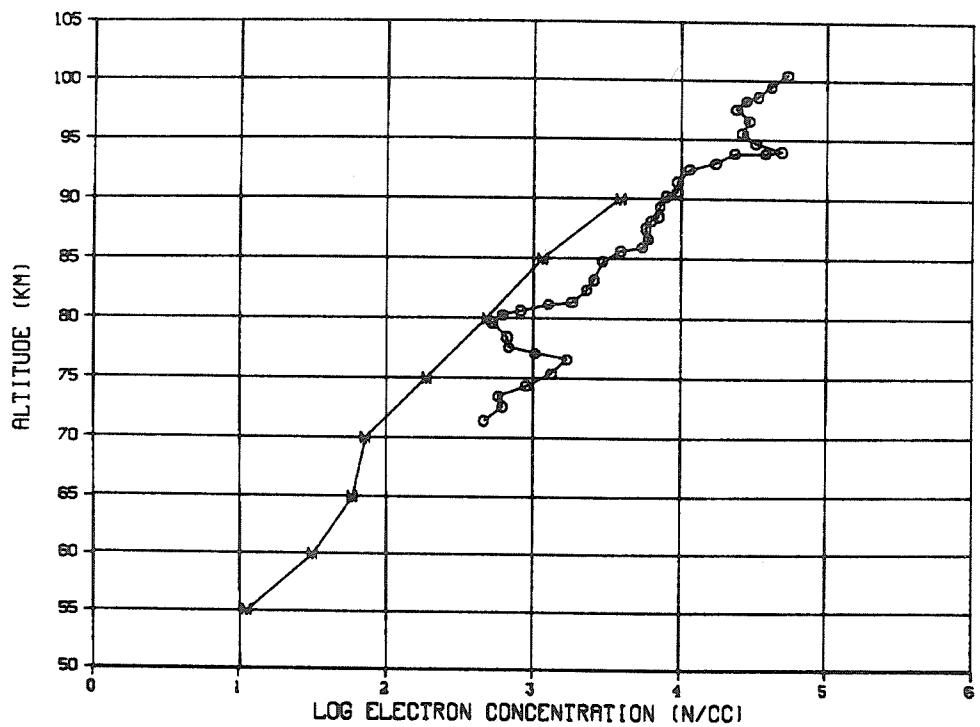


SOLAR ECLIPSE. MAXIMUM OBSERVATION 90% AT 1338 LT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 518 72 10 25 1208 61 37.1 353.3 2 1 48 4A 4  
 REFERENCE (R) 517 72 10 18 1200 61 37.1 353.3 2 1 48 4A 0  
 MODEL (M)

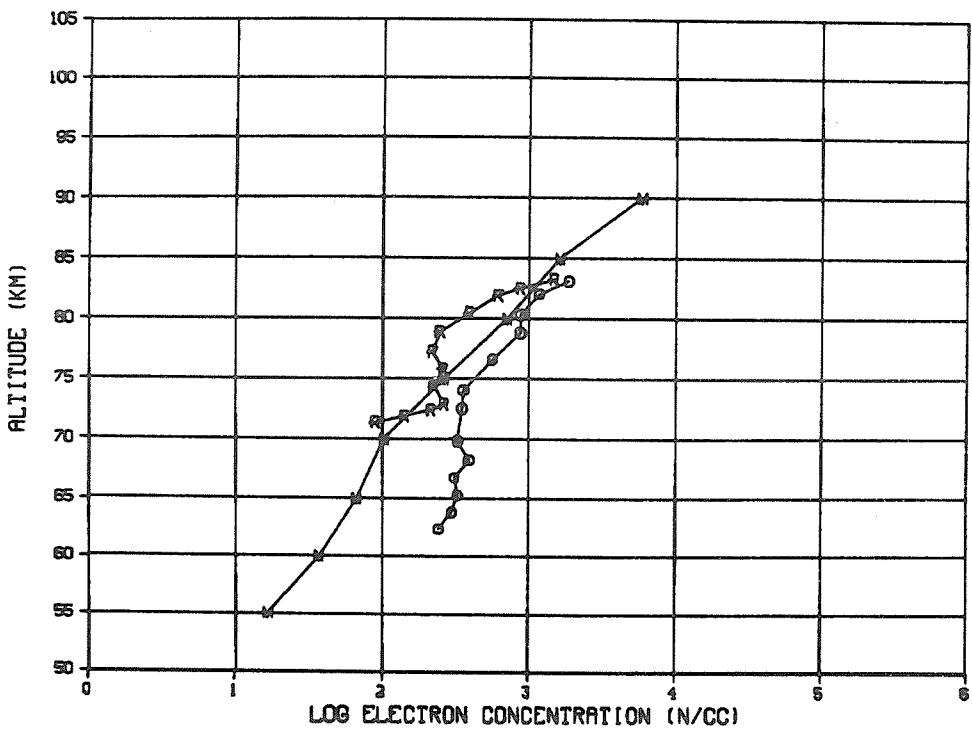


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 920 68 1 16 1514 103 37.9 284.5 2 1 2 4 3  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

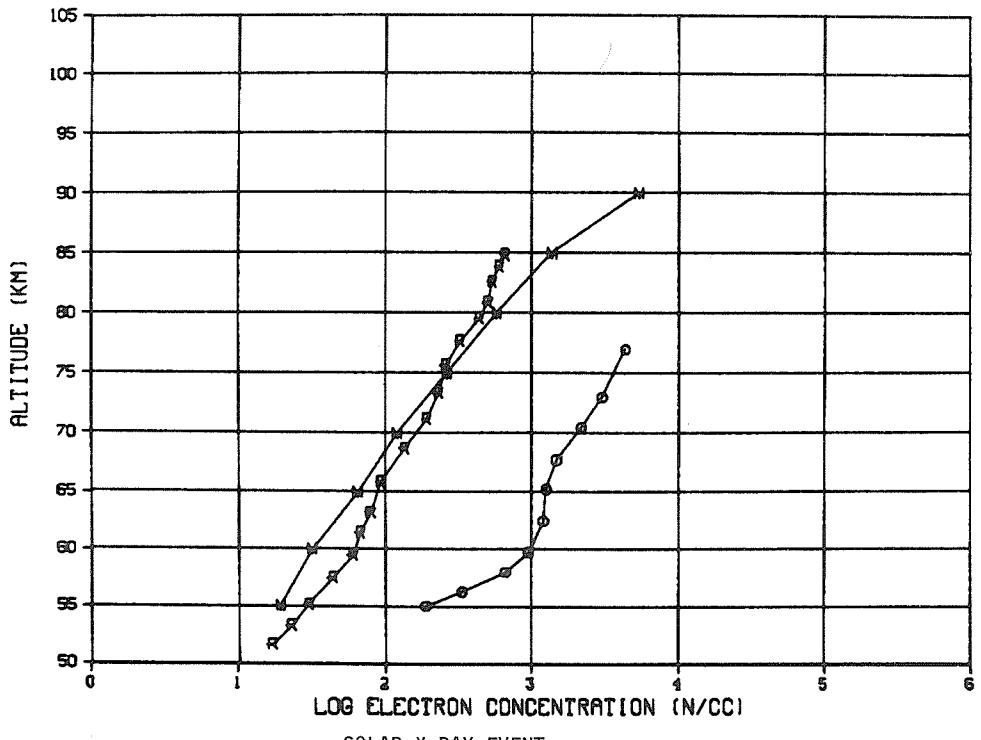


SOLAR X-RAY EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 541 72 1 19 1147 71 37.9 284.5 1 1 43 5.12 2  
 REFERENCE (R) 540 72 1 19 1109 71 37.9 284.5 1 1 43 5.12 0  
 MODEL (M)

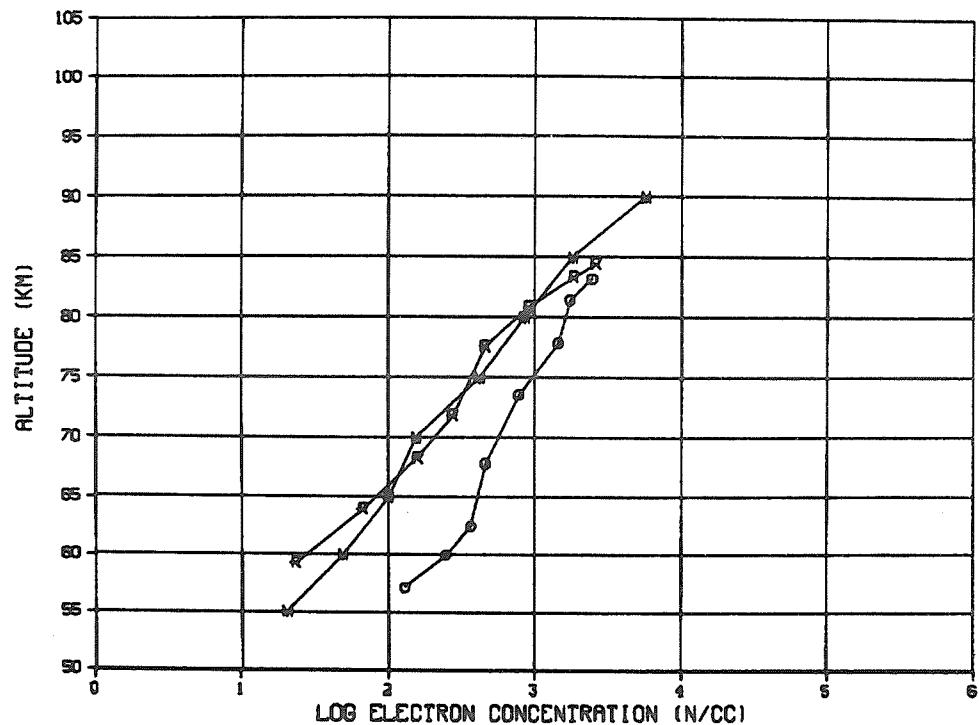


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 922 62 3 1 1147 40 45.4 284.1 1 1 14 8 4  
 REFERENCE (R) 54 62 3 0 1200 40 45.4 284.1 1 1 15 3.6 0  
 MODEL (M)

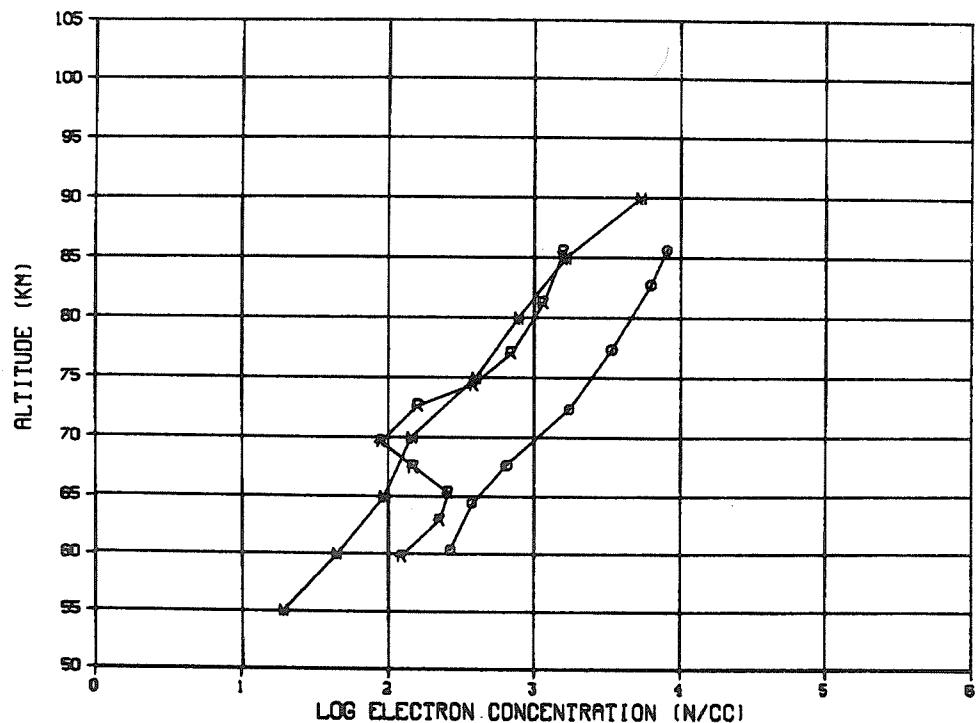


SOLAR X-RAY EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 324 68 3 25 1010 105 45.4 284.1 1 1 127 D1 2  
 REFERENCE (R) 323 68 3 25 945 105 45.4 284.1 1 1 127 D1 0  
 MODEL (M)

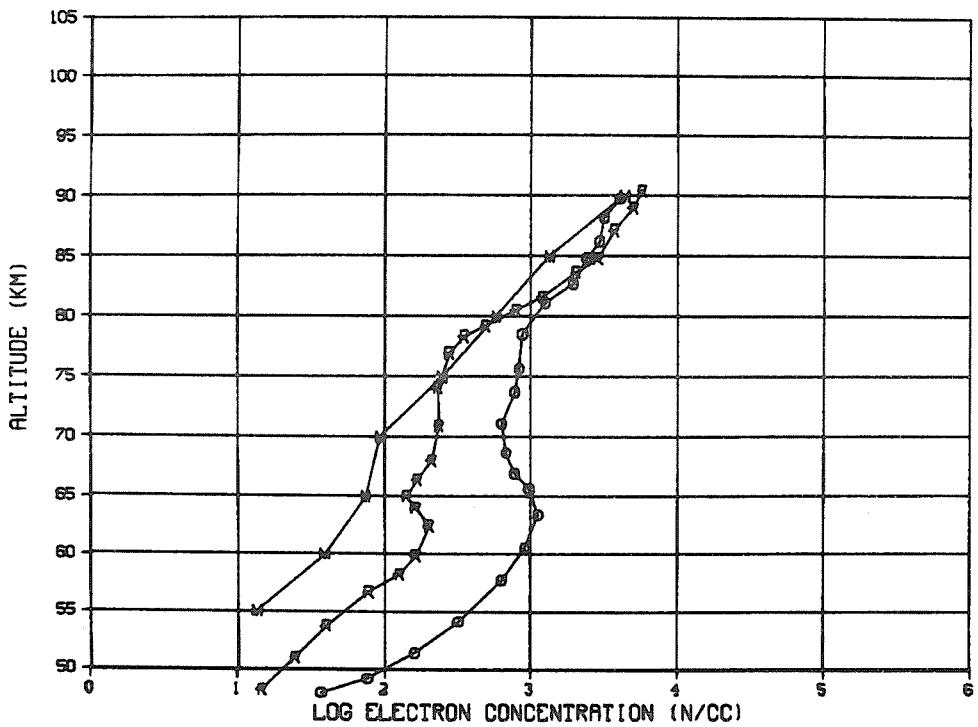


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 64 68 10 21 1239 110 40.8 282.1 3 1 115 1 2  
 REFERENCE (R) 63 68 10 21 1210 110 40.8 282.1 3 1 115 1 0  
 MODEL (M)

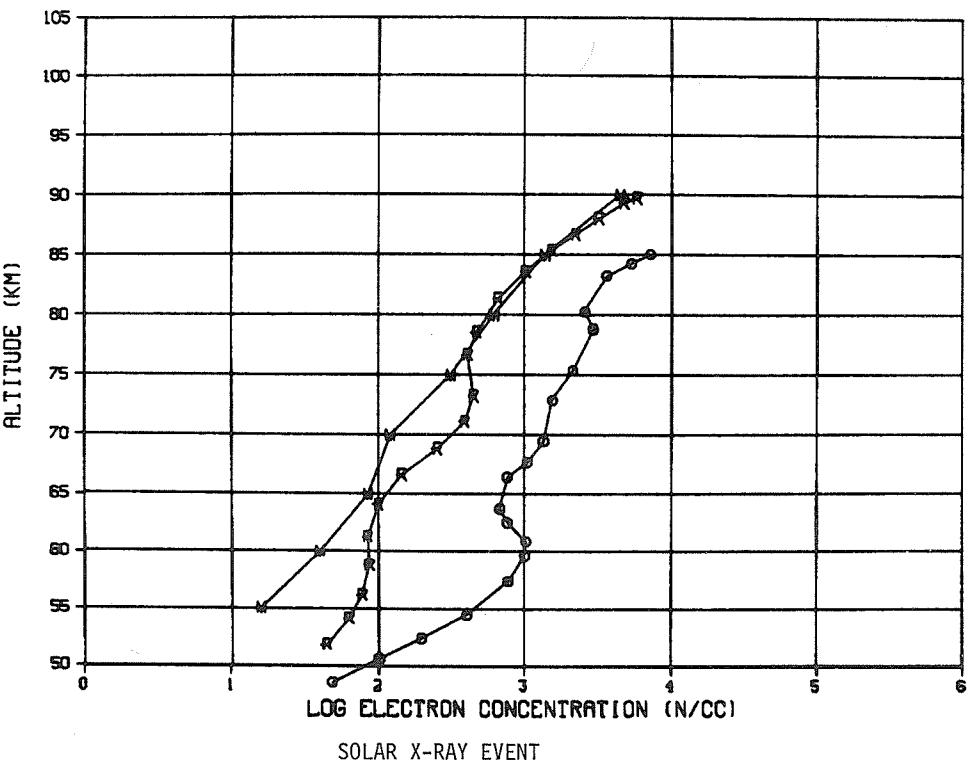


SOLAR X-RAY EVENT

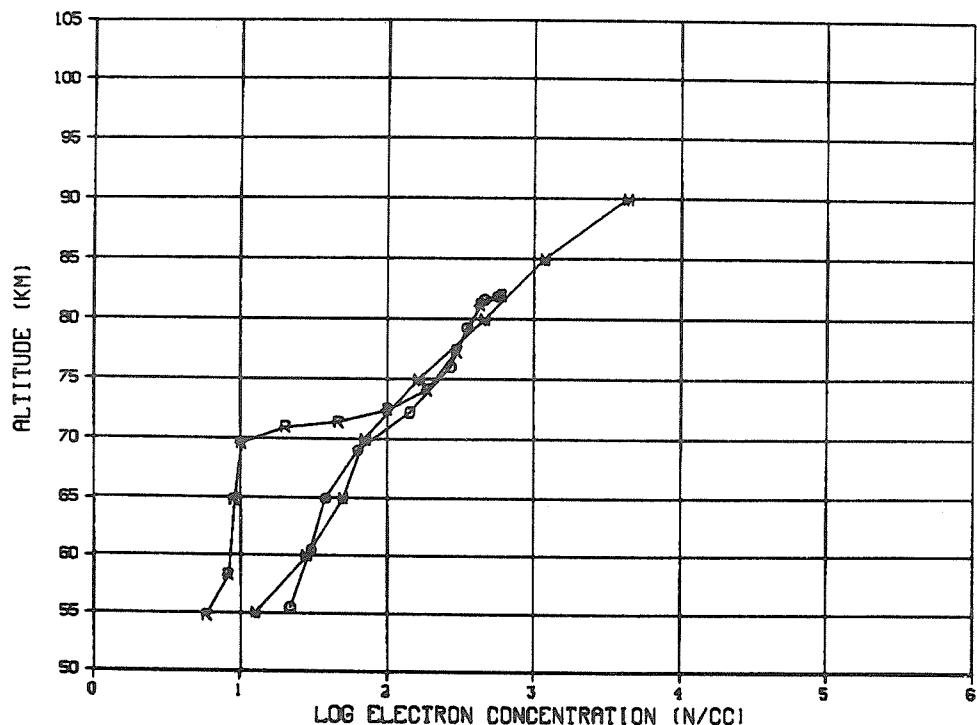
	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	945	69	11	18	1250	105	45.4	284.1	1	1	98	2	3
REFERENCE (R)	946	69	11	18	1430	105	45.4	284.1	1	1	98	2	0
MODEL (M)													



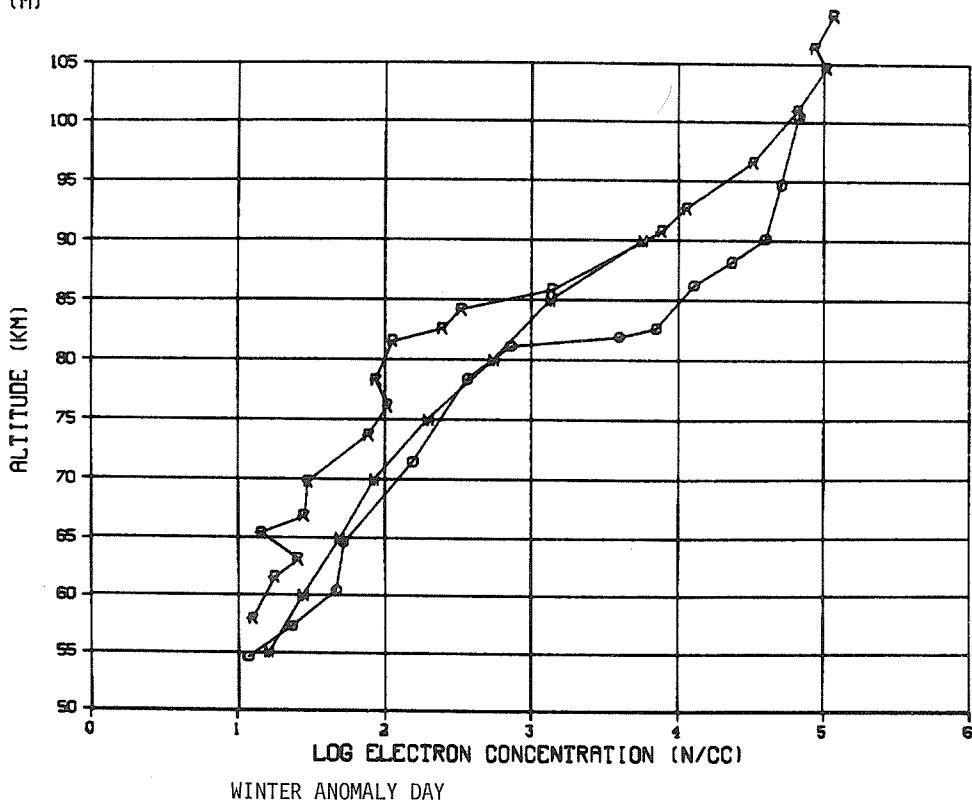
	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	406	70	3	1	1009	106	45.4	284.1	1	1	98	3	3
REFERENCE (R)	405	70	3	1	1003	106	45.4	284.1	1	1	98	3	0
MODEL (M)													



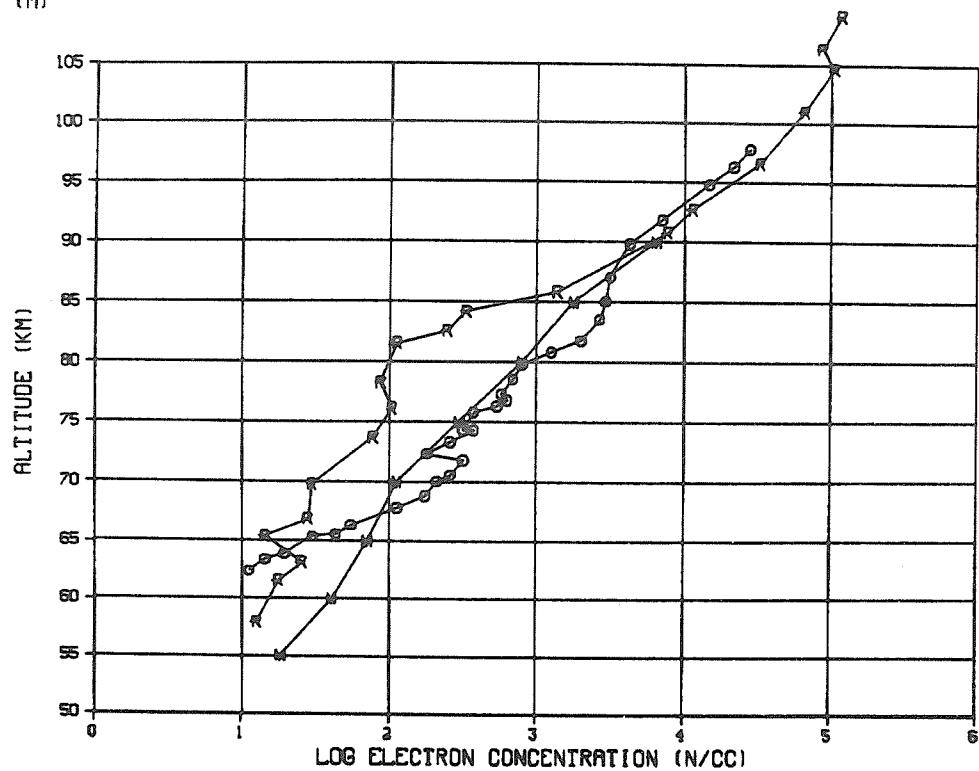
	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	48	61	12	18	1200	49	45.4	284.1	1	1	92	8	5
REFERENCE (R)	49	61	12	18	1200	49	45.4	284.1	1	1	92	8	0
MODEL (M)													



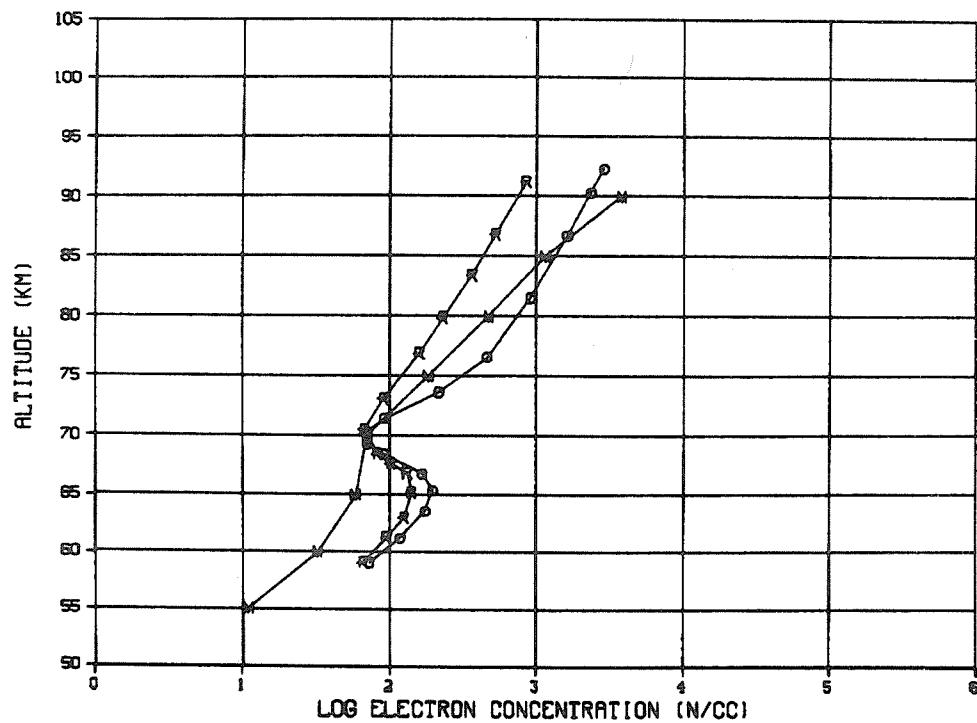
	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	221	66	1	10	1200	28	37.9	284.5	2	1	90	1	5
REFERENCE (R)	220	65	12	15	1200	24	37.9	284.5	2	1	90	1	0
MODEL (M)													



CURVE YR MO DY TIME SSNO LAT LONG MEIH MAG REF FIG SPC  
 OBSERVED (O) 268 67 1 31 1200 75 37.9 284.5 2 1 119 3 5  
 REFERENCE (R) 220 65 12 15 1200 24 37.9 284.5 2 1 90 1 0  
 MODEL (M)

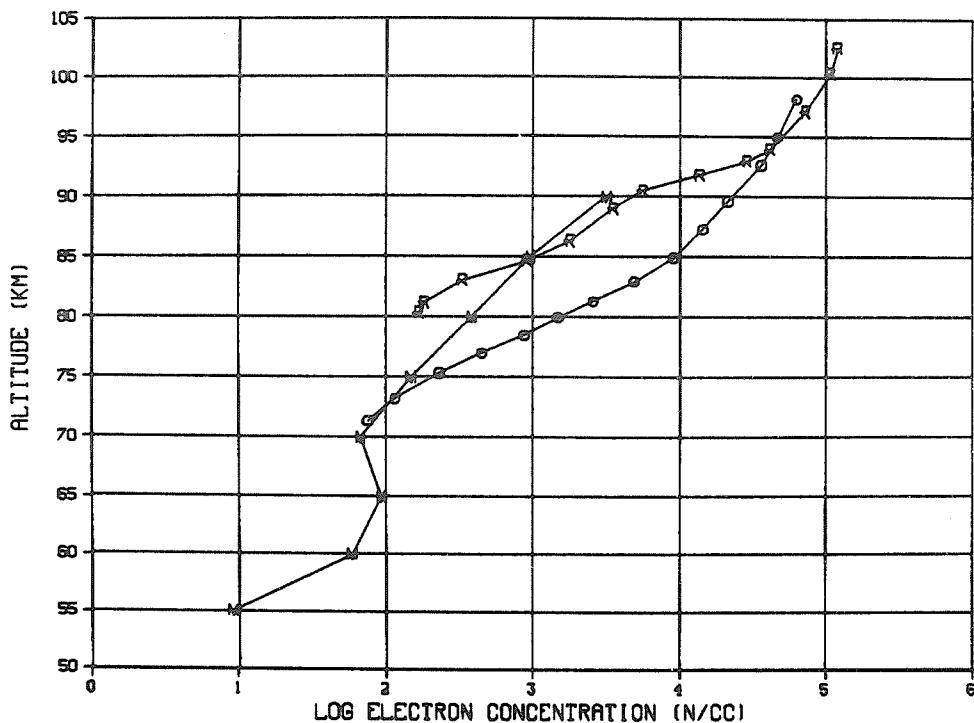


CURVE YR MO DY TIME SSNO LAT LONG MEIH MAG REF FIG SPC  
 OBSERVED (O) 288 68 1 8 1500 102 40.8 282.1 3 1 116 3 5  
 REFERENCE (R) 287 67 12 14 900 102 40.8 282.1 3 1 116 3 0  
 MODEL (M)

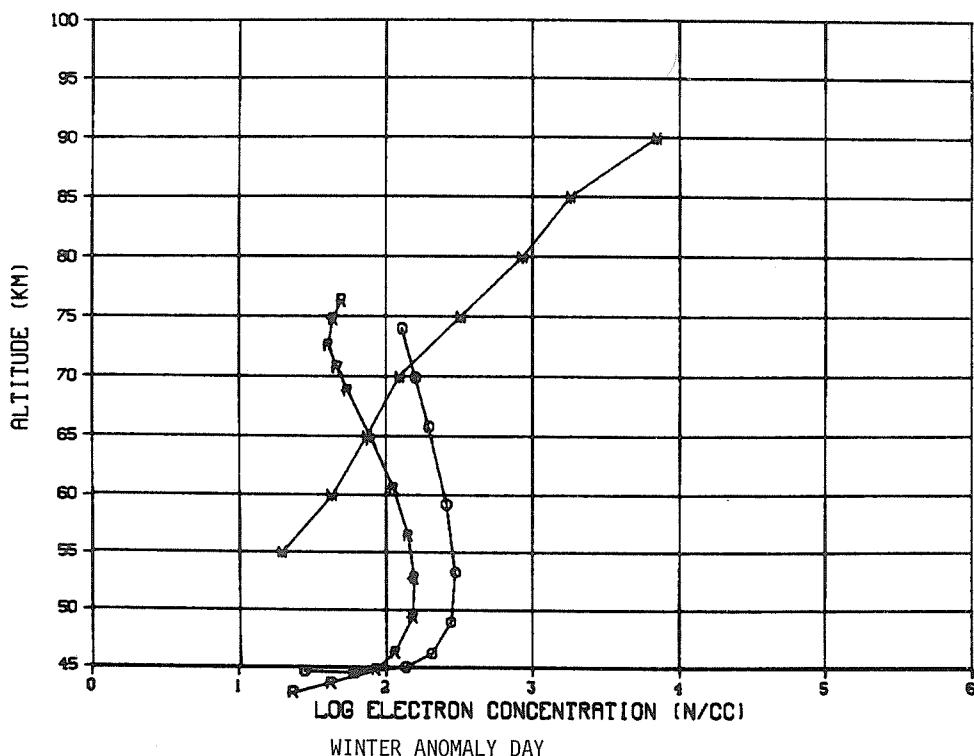


WINTER ANOMALY DAY

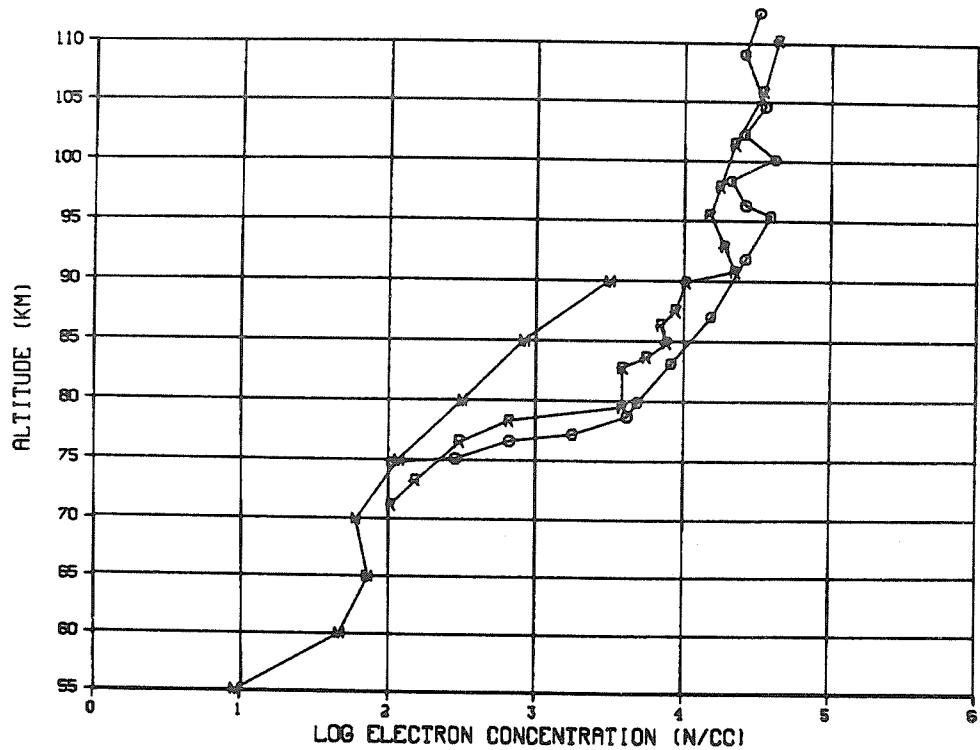
	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	548	68	12	5	1200	110	57.2	352.7	2	1	32	1	5
REFERENCE (R)	583	71	10	14	1255	66	57.4	352.6	2	1	33	4	0
MODEL (M)													



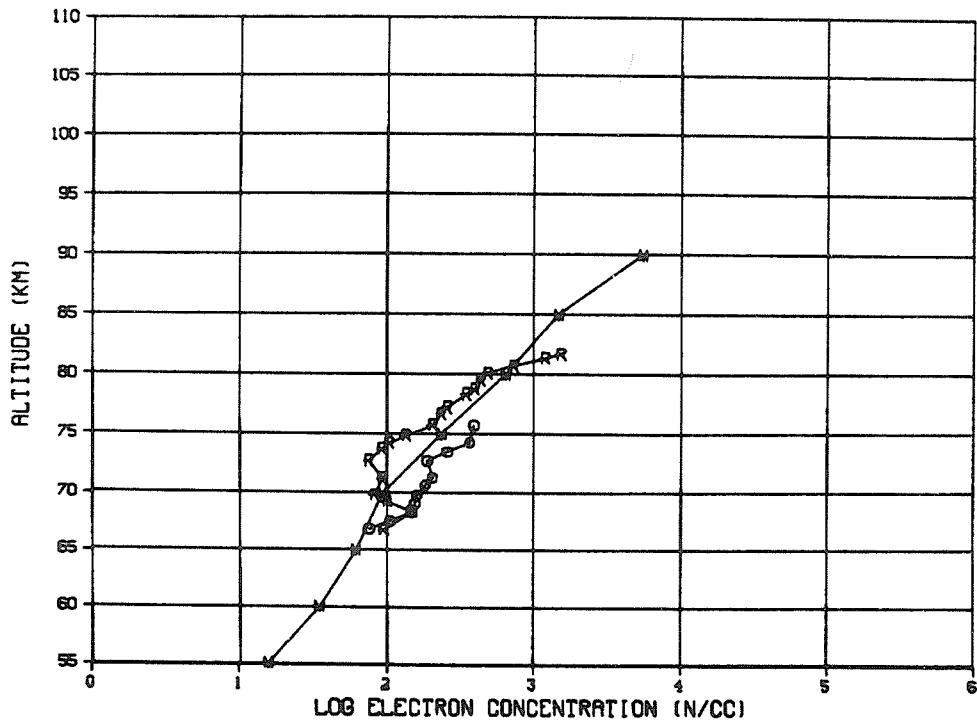
	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	450	71	1	22	1200	80	32.3	253.5	2	1	96	7	5
REFERENCE (R)	451	71	2	1	1215	78	32.3	253.5	2	1	96	7	0
MODEL (M)													



	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	992	71	12	3	1258	69	57.2	352.9	2	1	151	2	5
REFERENCE (R)	991	71	12	1	1334	69	57.2	352.9	2	1	151	2	0
MODEL (M)													

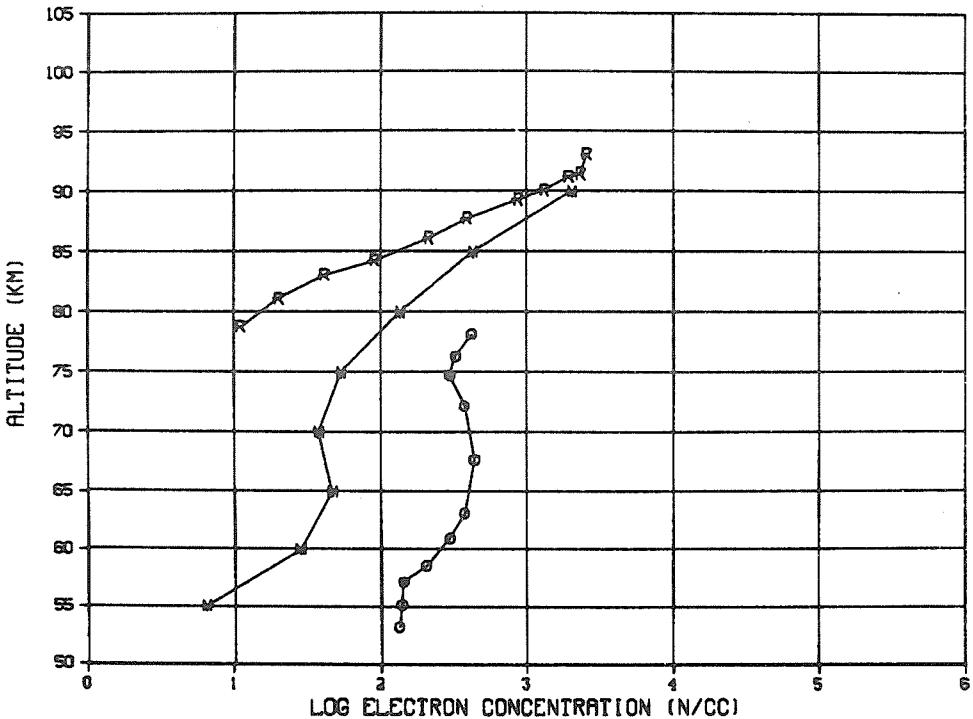


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	545	71	12	12	1200	69	37.9	284.5	1	1	43	5.7	5
REFERENCE (R)	544	71	12	9	1200	69	40.1	271.8	1	1	43	5.7	0
MODEL (M)													

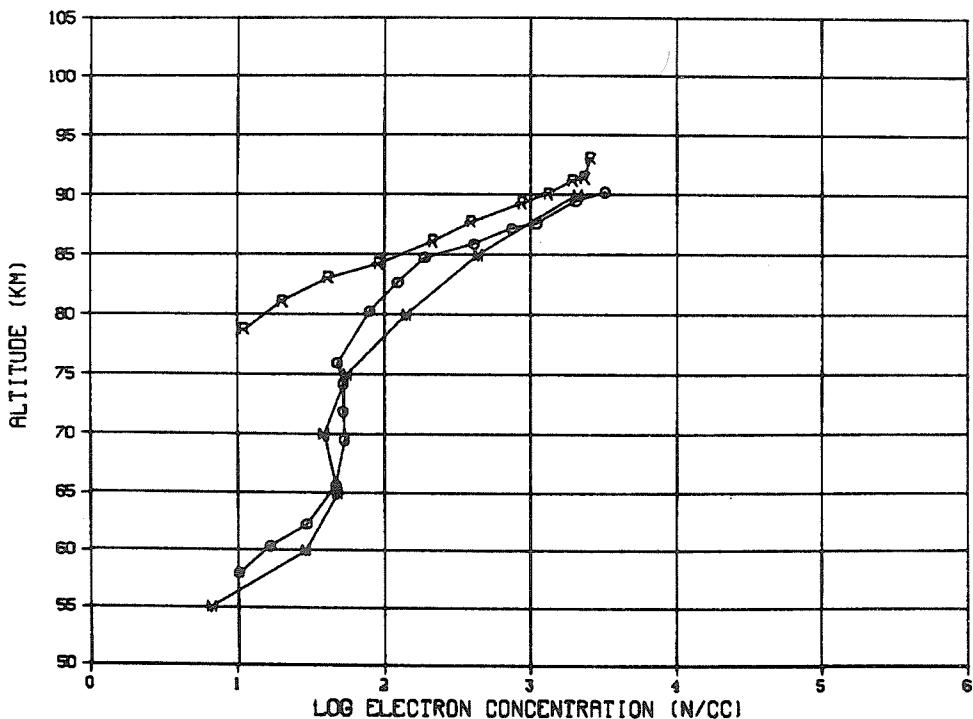


WINTER ANOMALY DAY

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)		158	65	2	6	1200	12	74.7	265.1	1	1 68	2	7
REFERENCE (R)		160	65	2	11	1200	12	74.7	265.1	1	1 68	2	0
MODEL (M)													

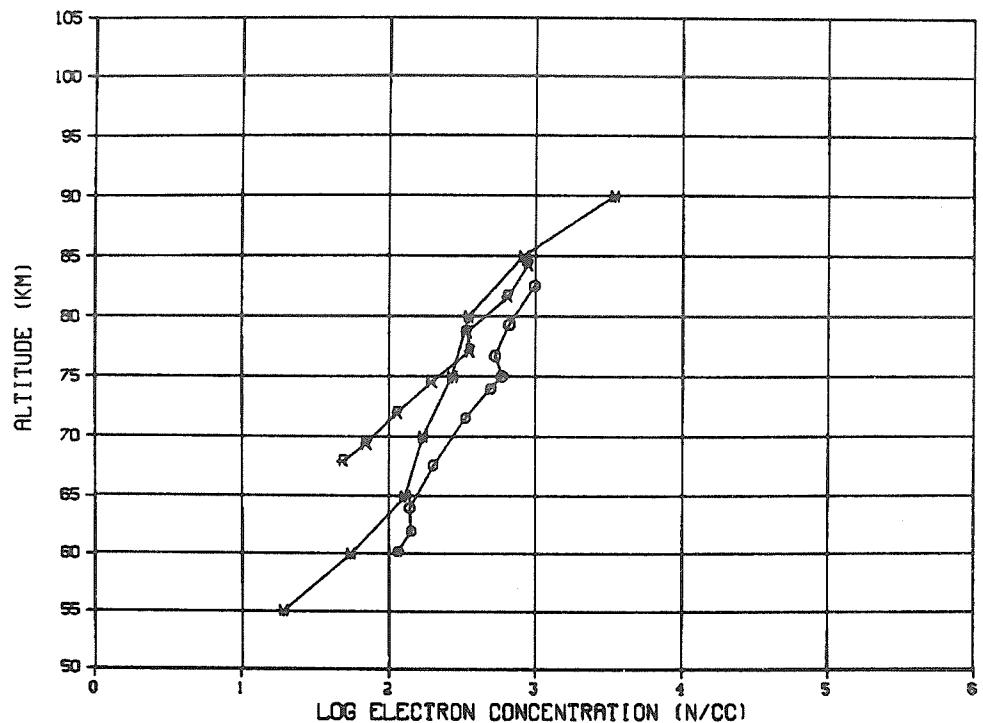


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)		159	65	2	8	1200	12	74.7	265.1	1	1 68	2	7
REFERENCE (R)		160	65	2	11	1200	12	74.7	265.1	1	1 68	2	0
MODEL (M)													

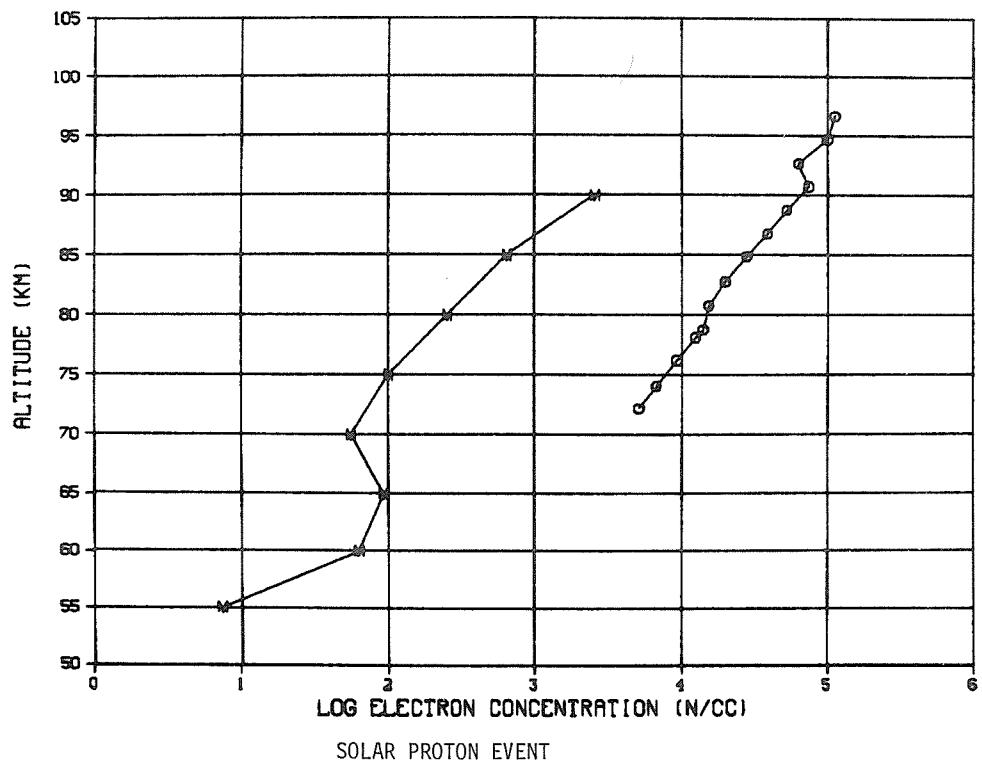


SOLAR PROTON EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
OBSERVED (O) 938 66 7 17 1200 50 74.7 265.1 1 1 68 4 7  
REFERENCE (R) 250 66 7 15 1200 50 74.7 265.1 1 1 68 4 0  
MODEL (M)

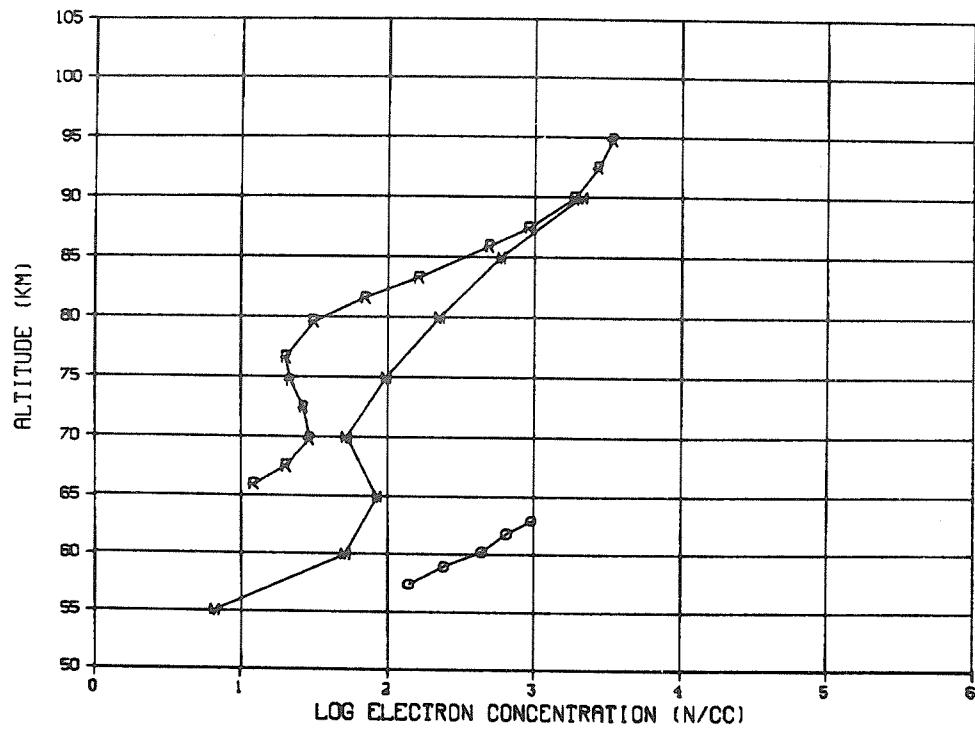


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
OBSERVED (O) 932 67 1 29 1030 91 -66.7 140.0 2 1 31 19.6 7  
REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0.0 0 0 0 0 0  
MODEL (M)

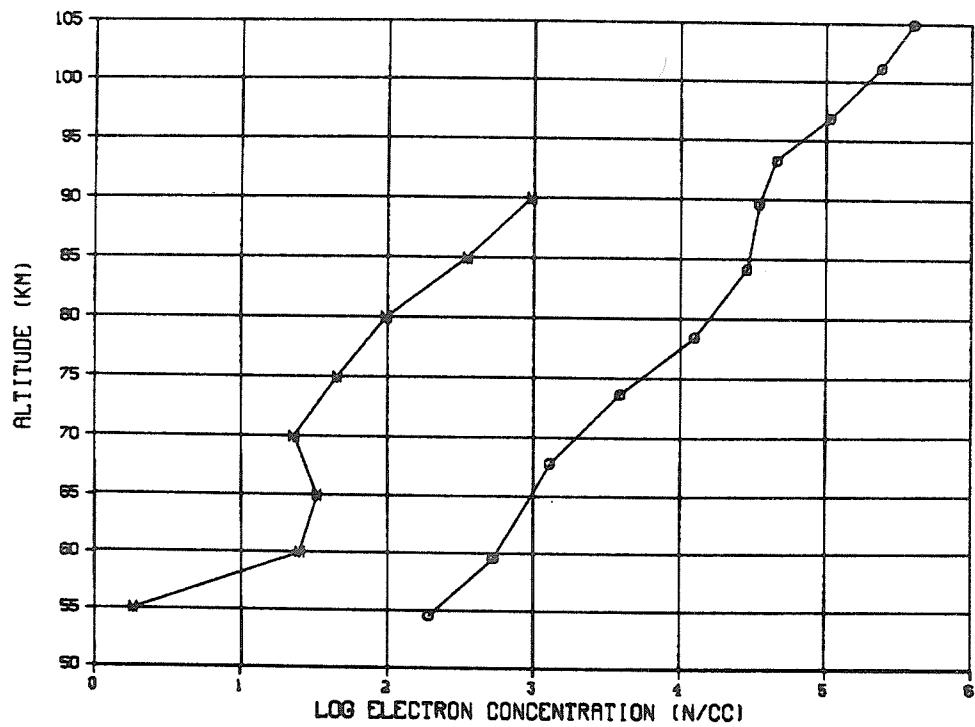


SOLAR PROTON EVENT

CURVE YR MO DY TIME SSNO LAT LONG MEIH MAG REF FIG SPC  
 OBSERVED (O) 358 68 11 1 1200 111 74.7 265.1 1 1 27 14 7  
 REFERENCE (R) 354 68 10 25 1200 110 74.7 265.1 1 1 27 14 0  
 MODEL (M)

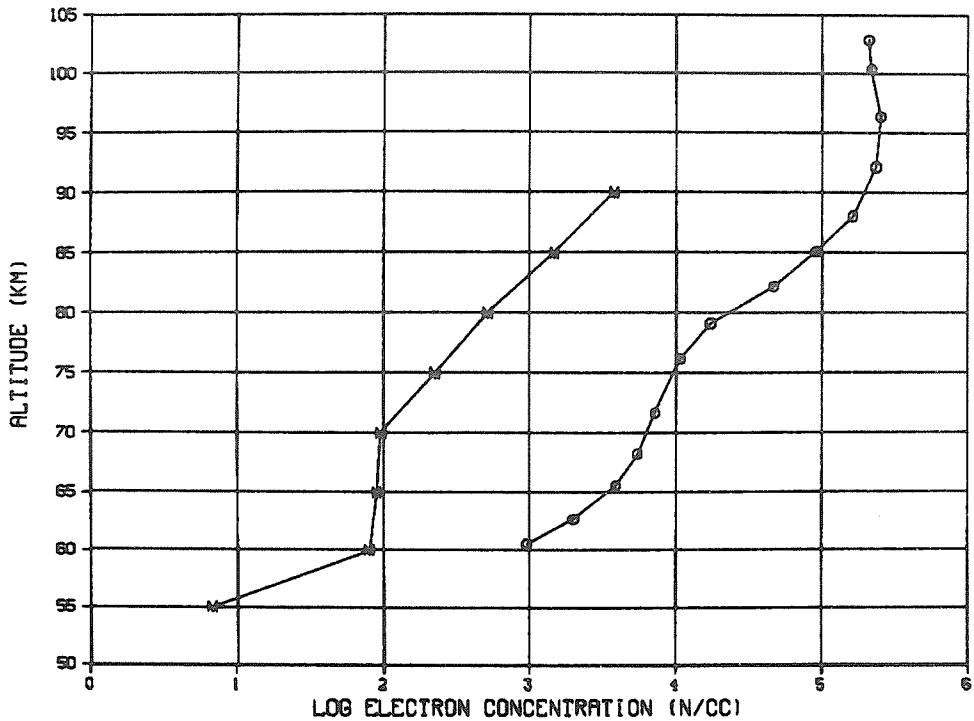


CURVE YR MO DY TIME SSNO LAT LONG MEIH MAG REF FIG SPC  
 OBSERVED (O) 382 69 11 3 5 105 58.8 265.8 2 2 138 27.5 8  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

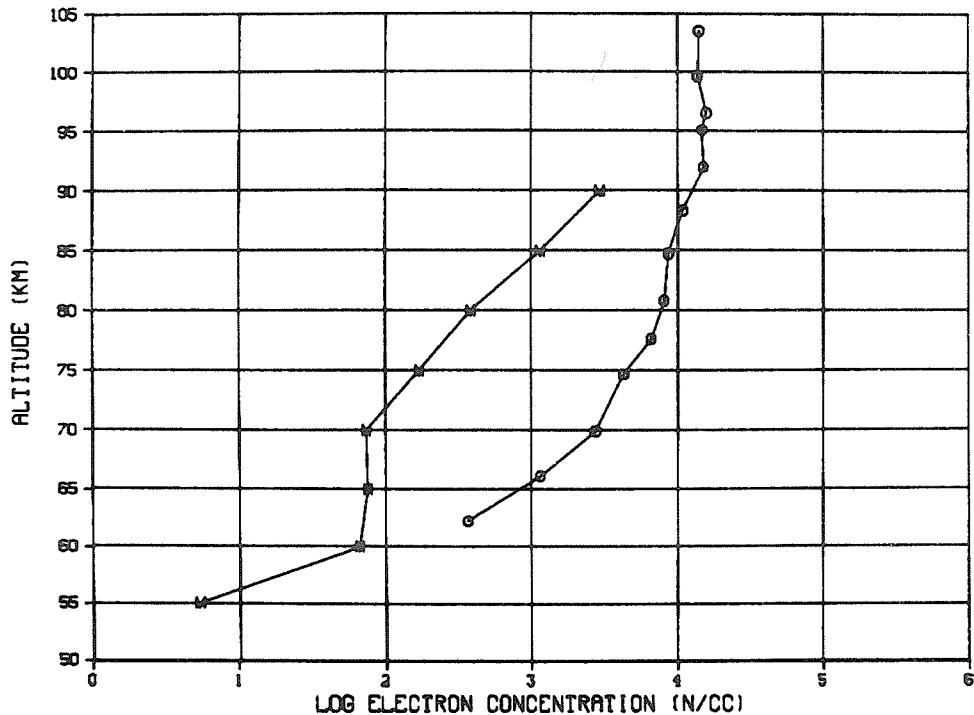


SOLAR PROTON EVENT

CURVE YR MO DY TIME SSNO LAT LONG MEIH MAG REF FIG SPC  
 OBSERVED (O) 385 69 11 3 752 105 58.8 265.8 2 2 138 27.6 8  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

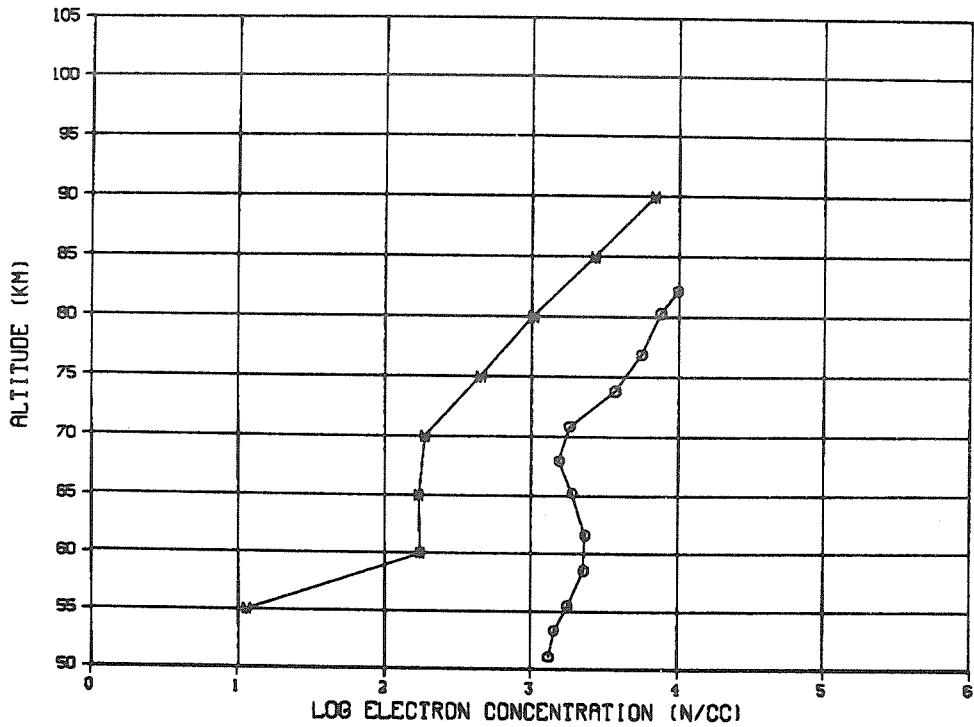


CURVE YR MO DY TIME SSNO LAT LONG MEIH MAG REF FIG SPC  
 OBSERVED (O) 390 69 11 4 1708 105 58.8 265.8 2 2 138 27.6 8  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

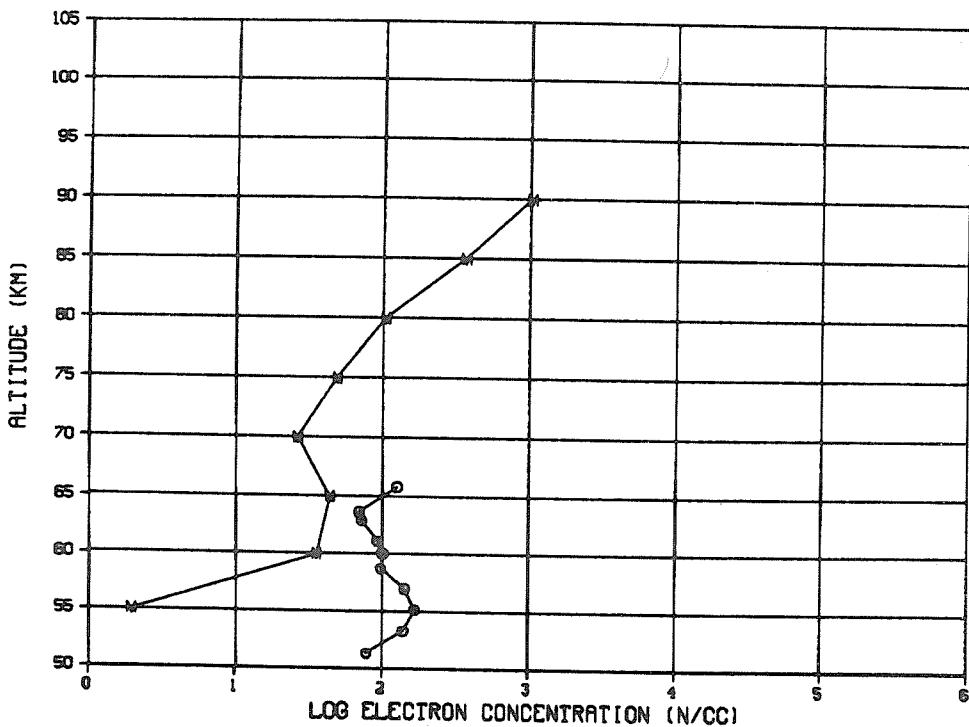


SOLAR PROTON EVENT

CURVE YR MO DY TIME SSNO LAT LONG MEIH MAG REF FIG SPC  
 OBSERVED (O) 366 69 2 25 1521 110 50.0 15.0 2 278 1 8  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

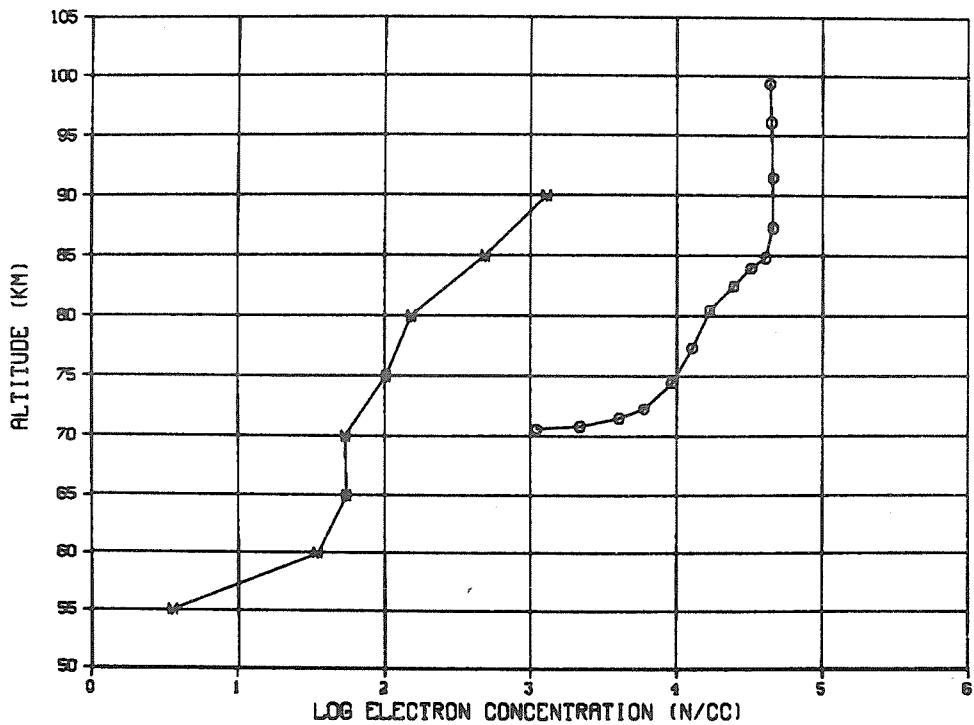


CURVE YR MO DY TIME SSNO LAT LONG MEIH MAG REF FIG SPC  
 OBSERVED (O) 365 69 2 25 2237 110 50.0 15.0 2 278 1 8  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

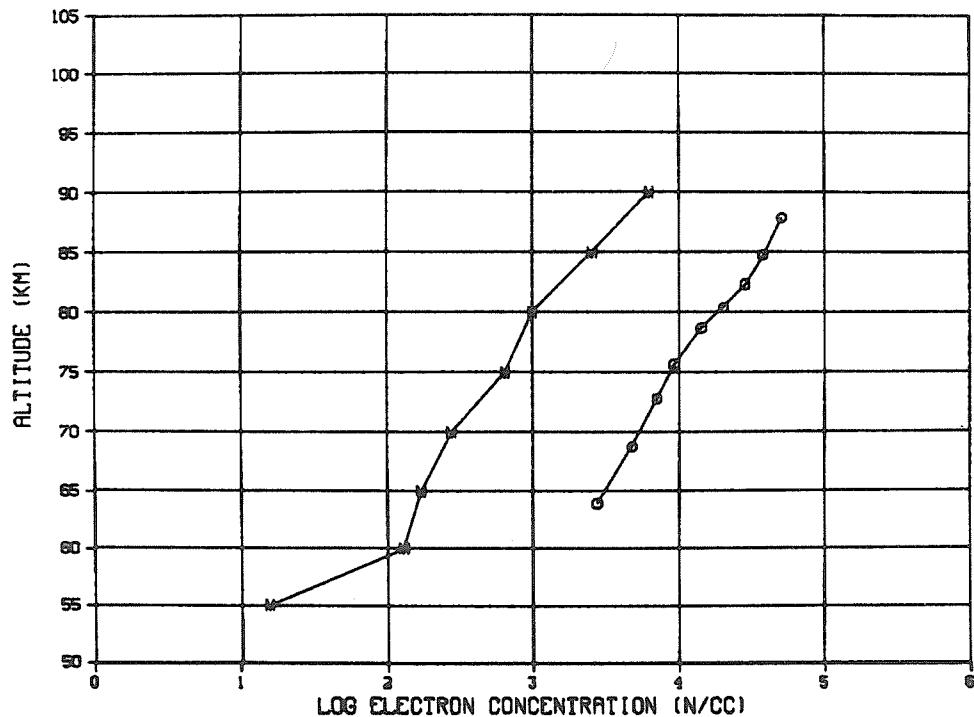


SOLAR PROTON EVENT

CURVE YR MO DY TIME SSNO LAT LONG MEIH MAG REF FIG SPC  
 OBSERVED (O) 369 69 4 13 2319 106 58.8 265.8 2 294 6 8  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

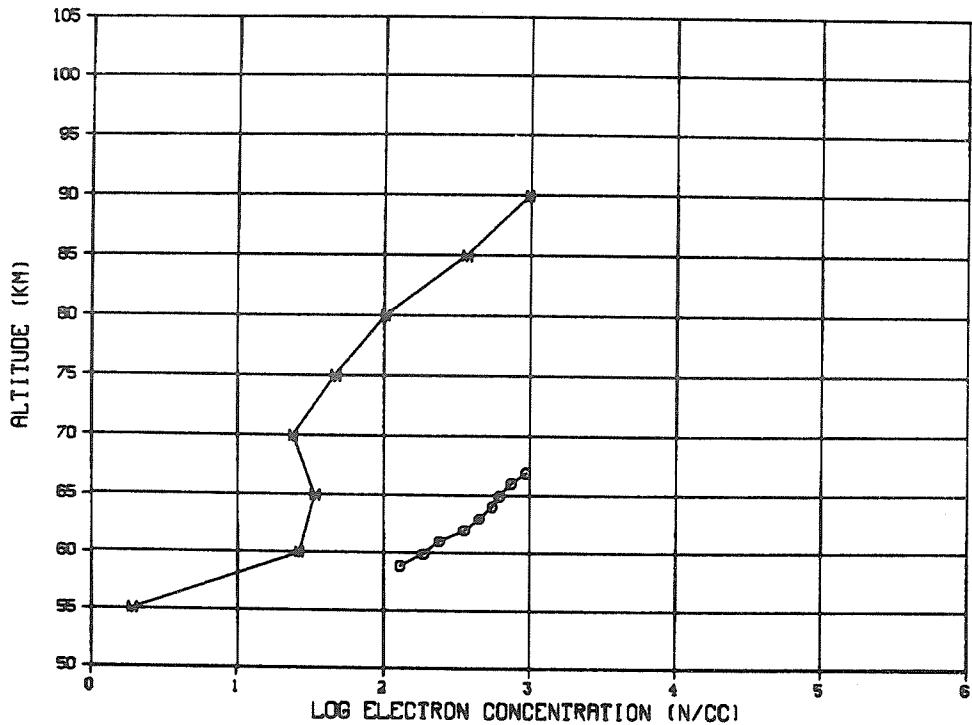


CURVE YR MO DY TIME SSNO LAT LONG MEIH MAG REF FIG SPC  
 OBSERVED (O) 368 69 4 14 1528 106 58.8 265.8 2 294 6 8  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

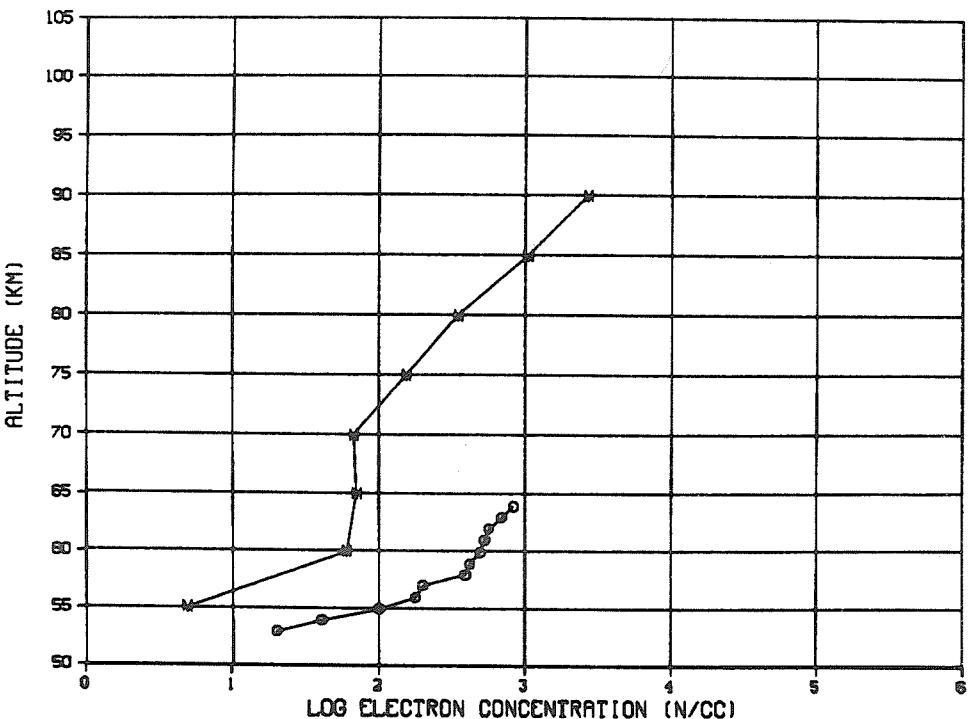


SOLAR PROTON EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 804 69 11 3 100 105 58.8 265.8 2 2 154 3-3 8  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

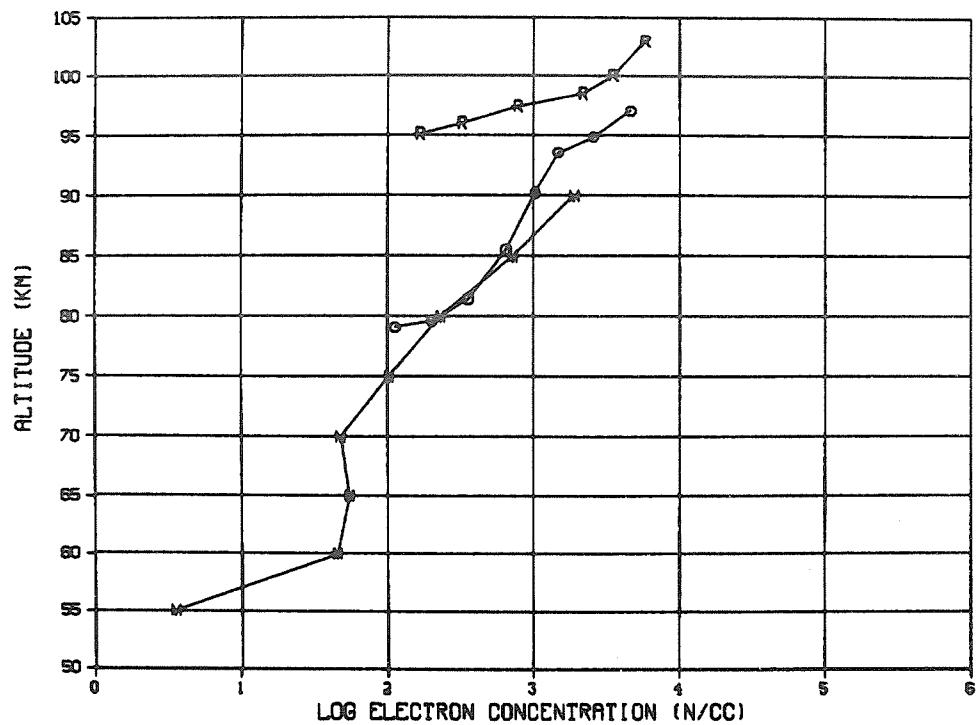


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 805 69 11 3 628 105 58.8 265.8 2 2 154 3-3 8  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

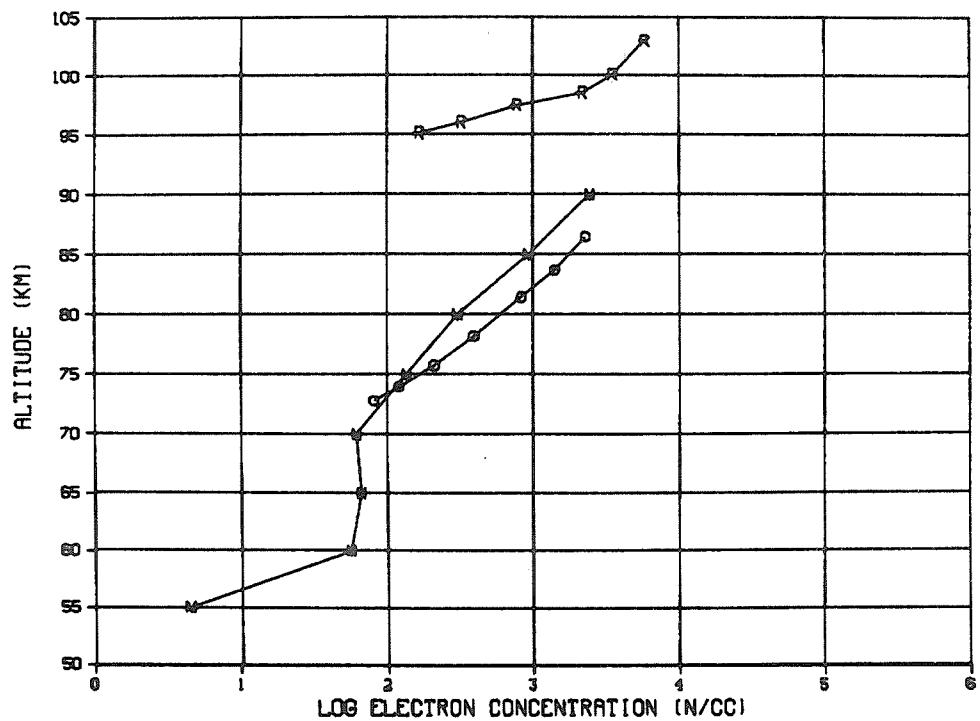


SOLAR PROTON EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
OBSERVED (O) 375 69 11 2 500 105 58.8 265.8 1 2 17 16.6 8  
REFERENCE (R) 925 69 11 2 400 105 58.8 265.8 1 2 17 16.6 0  
MODEL (M)

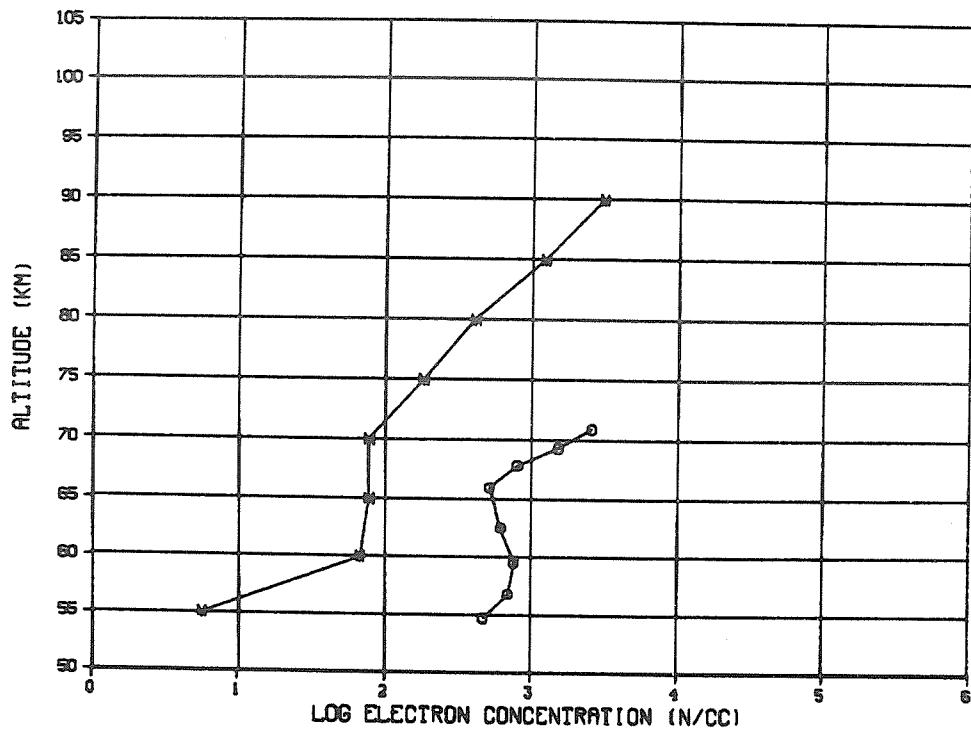


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
OBSERVED (O) 376 69 11 2 600 105 58.8 265.8 1 2 17 16.6 8  
REFERENCE (R) 925 69 11 2 400 105 58.8 265.8 1 2 17 16.6 0  
MODEL (M)

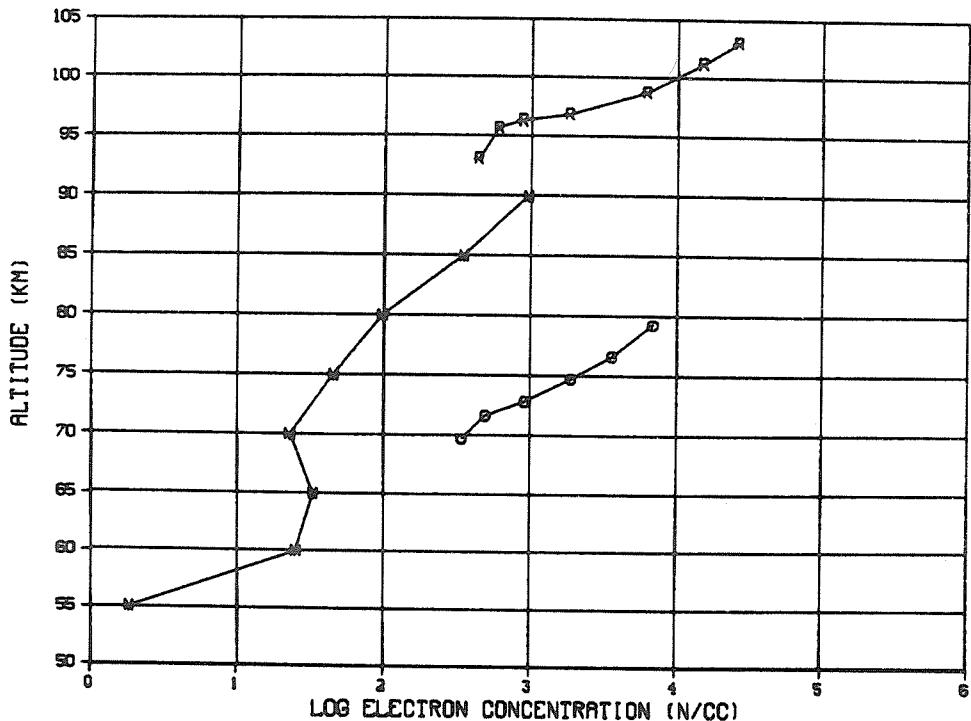


SOLAR PROTON EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 377 69 11 2 700 105 58.8 265.8 1 2 17 16.6 8  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0.0 0 0 0 0  
 MODEL (M)

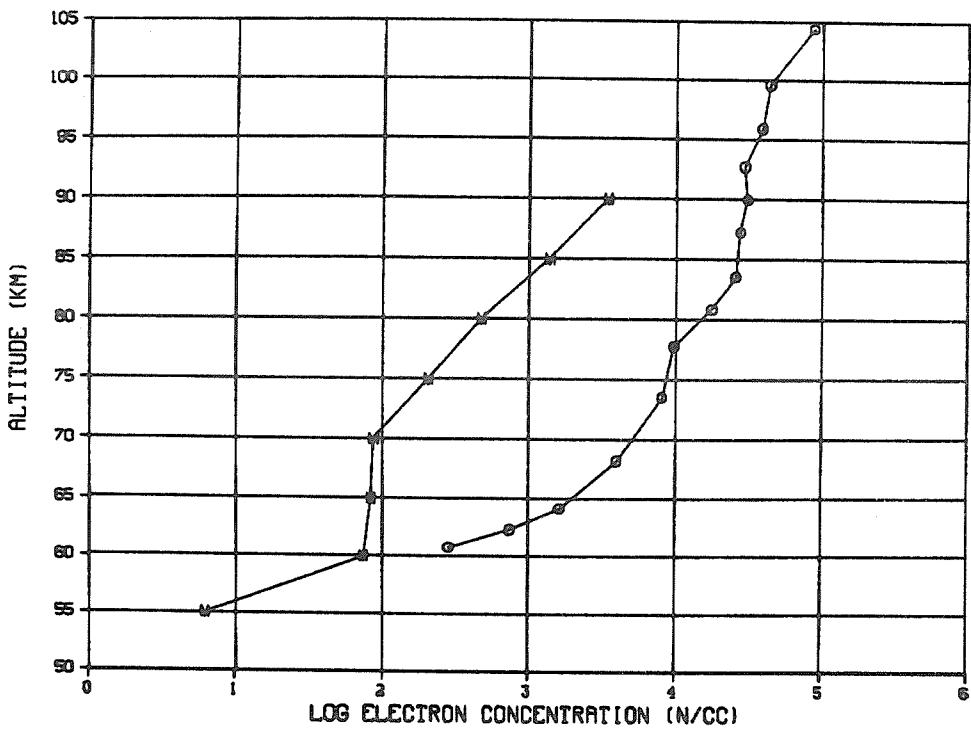


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 381 69 11 3 0 105 58.8 265.8 1 2 17 16.6 8  
 REFERENCE (R) 923 69 11 1 0 105 58.8 265.8 1 1 17 16.7 0  
 MODEL (M)

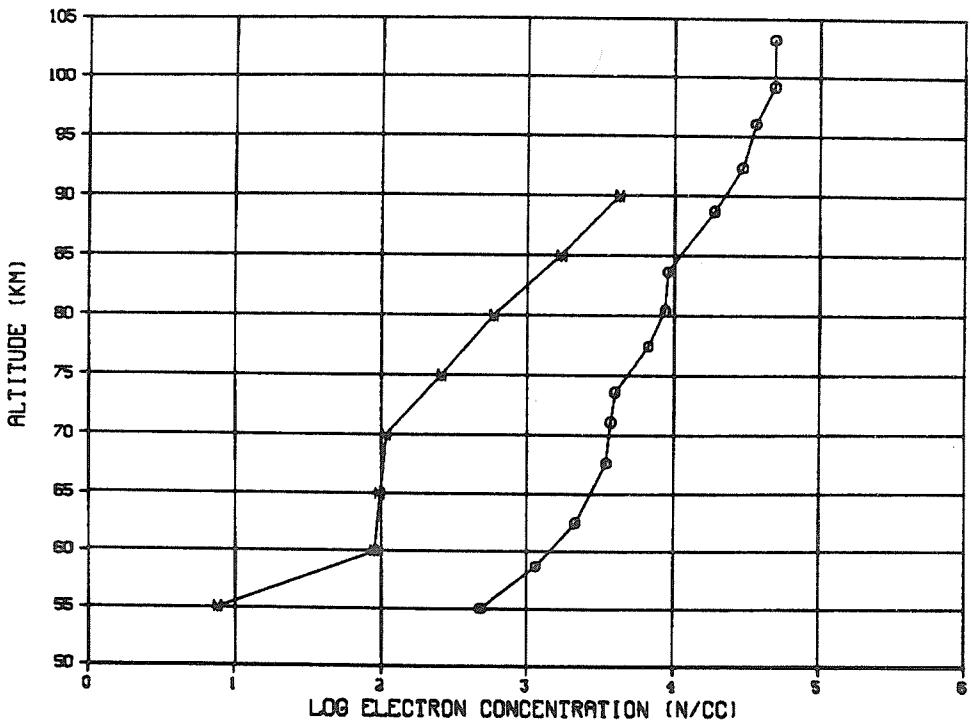


SOLAR PROTON EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 384 69 11 3 730 105 58.8 265.8 2 244 20.3 8  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

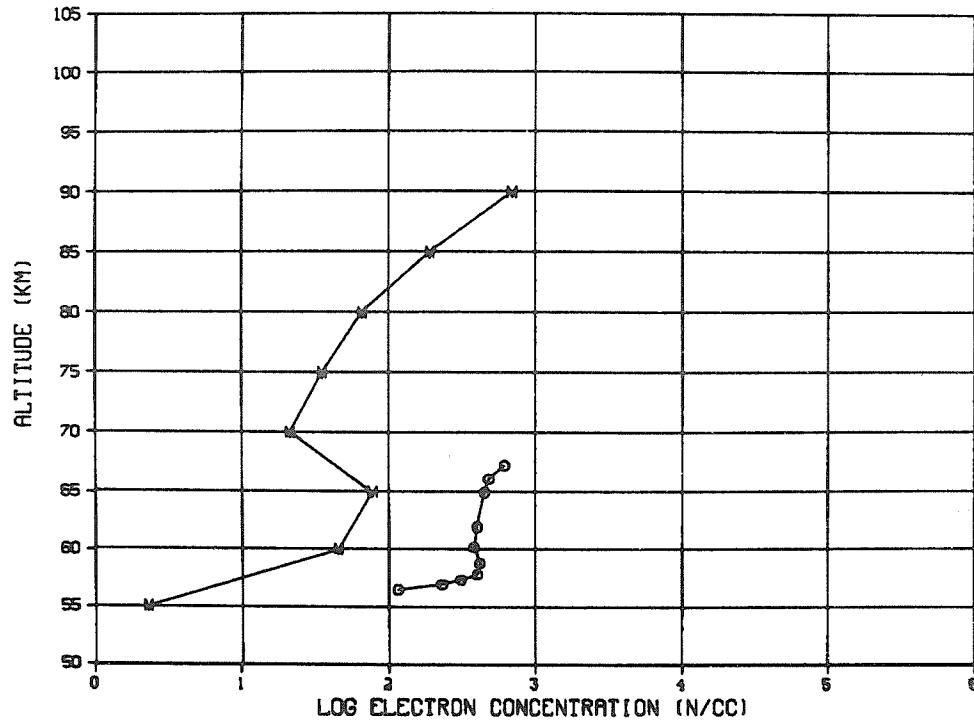


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 388 69 11 4 1530 105 58.8 265.8 2 244 20.6 8  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

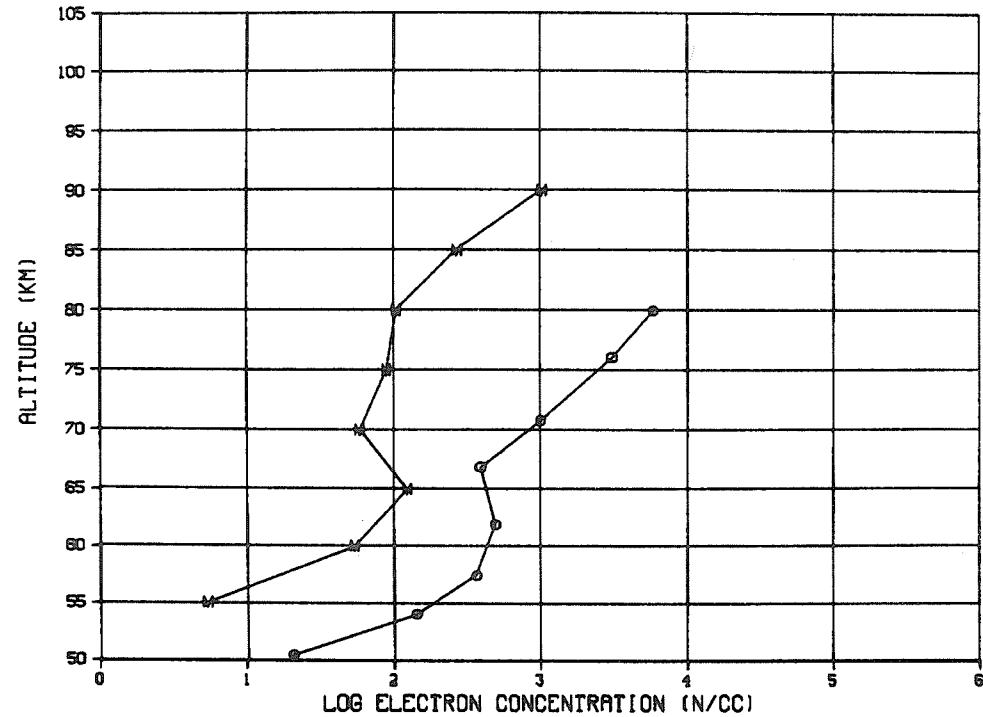


SOLAR PROTON EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 16 58 11 26 2100 181 69.7 19.0 3 172 6 12  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

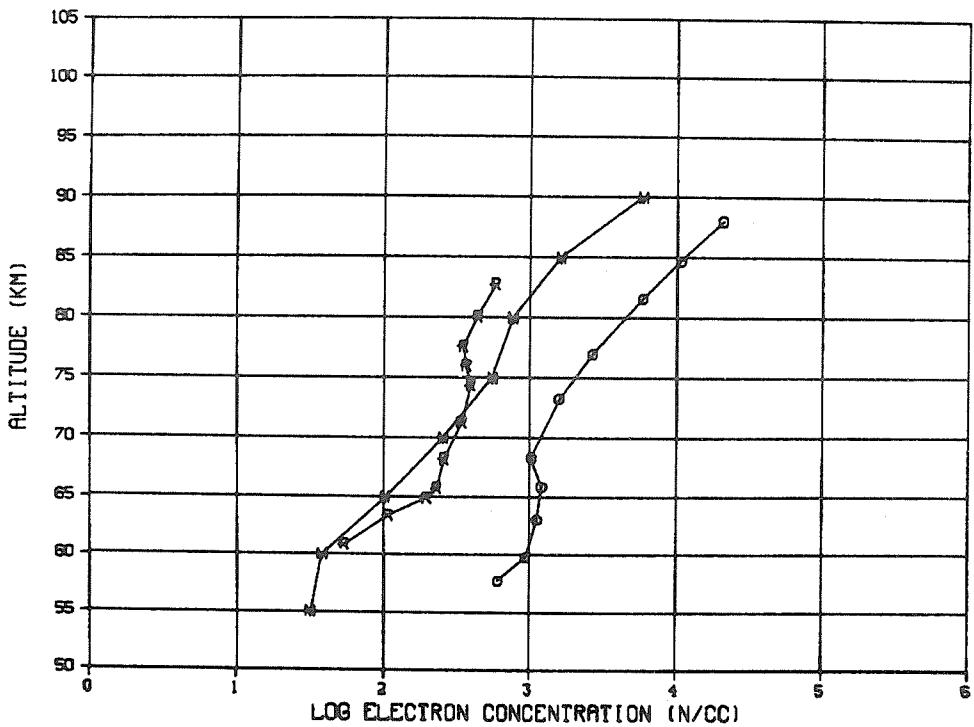


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 20 59 8 26 2120 151 69.7 19.0 3 172 11 12  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

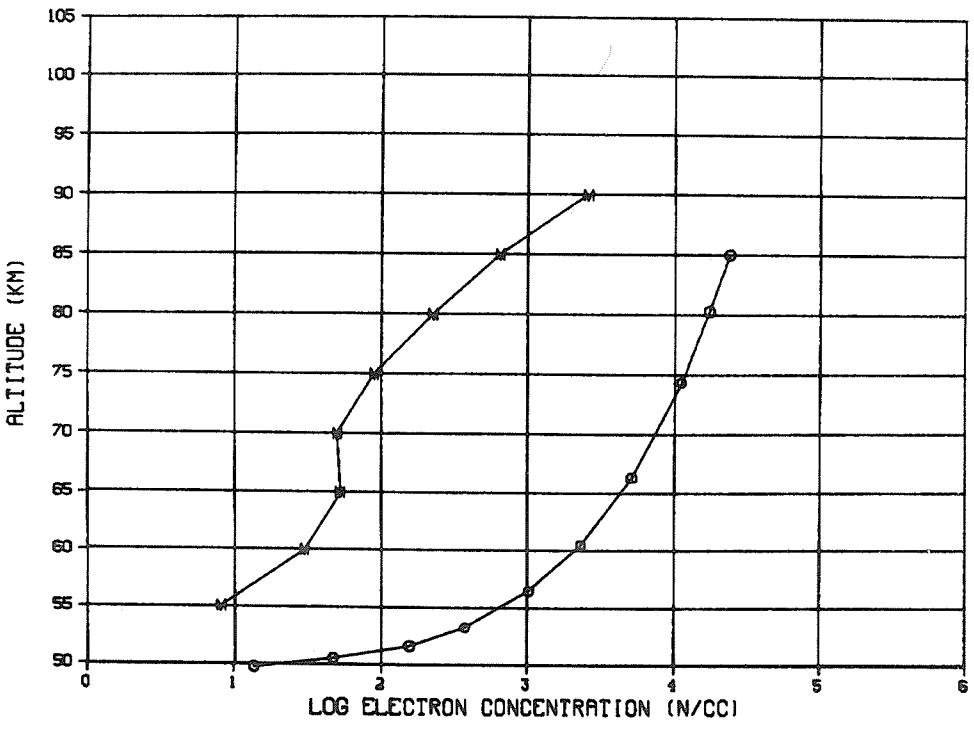


SOLAR PROTON EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 42 61 7 14 1100 53 45.4 284.1 1 1 14 9 9  
 REFERENCE (R) 41 61 6 0 1200 56 45.4 284.1 1 1 14 9 0  
 MODEL (M)

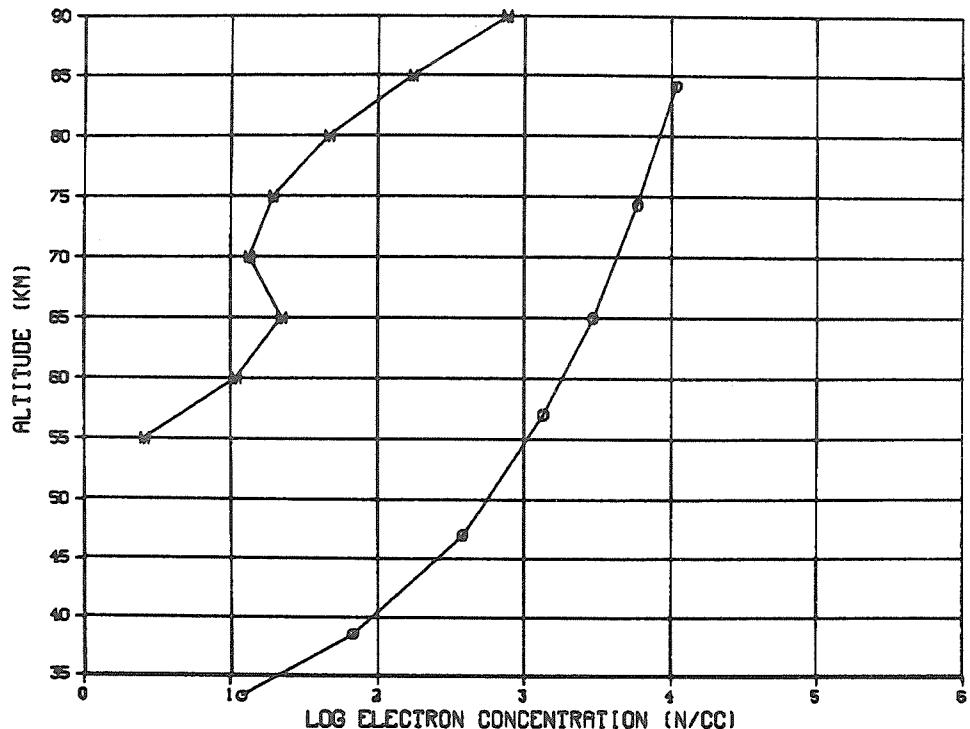


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 484 62 2 18 915 42 64.9 212.1 5 1 104 6 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

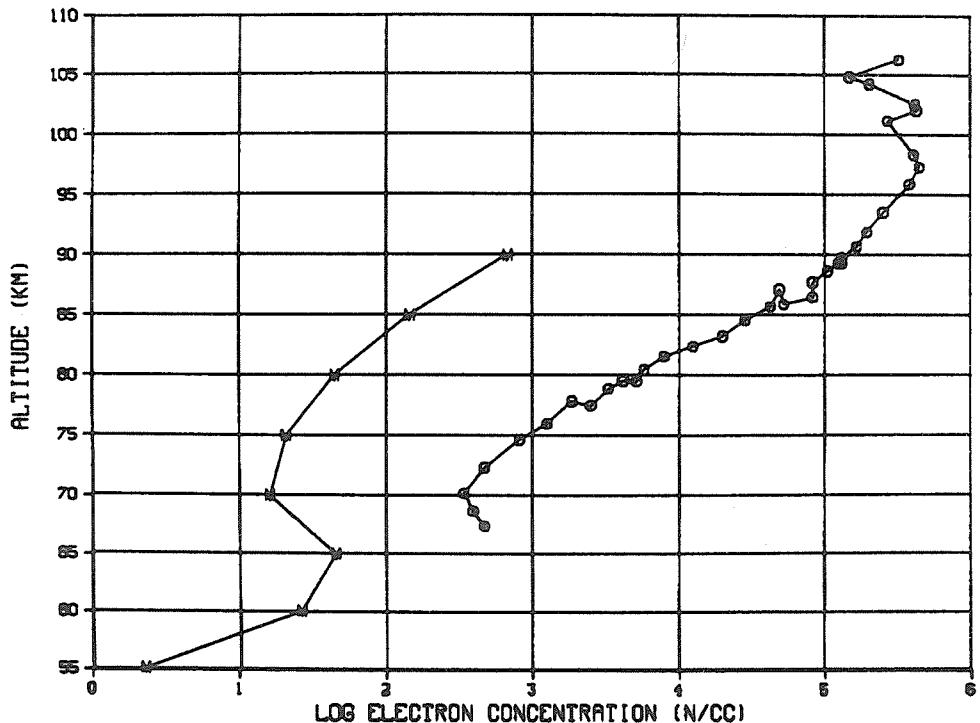


AURORAL ABSORPTION EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 487 62 2 23 140 42 64.9 212.1 5 1 104 6 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

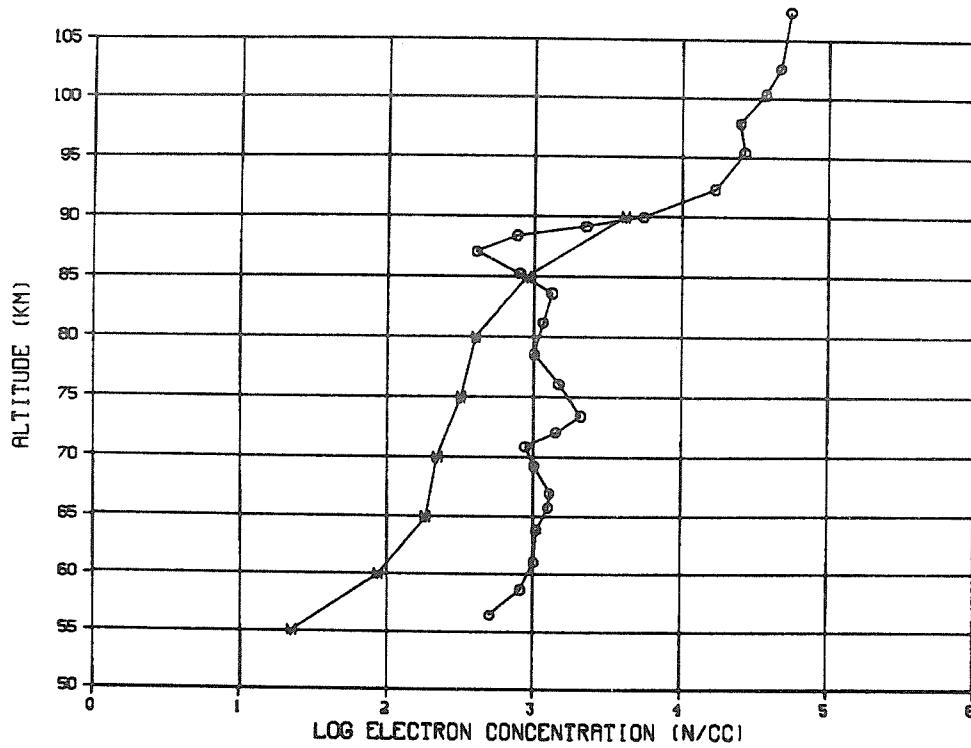


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 282 67 11 20 137 97 69.3 16.0 2 1 112 15 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

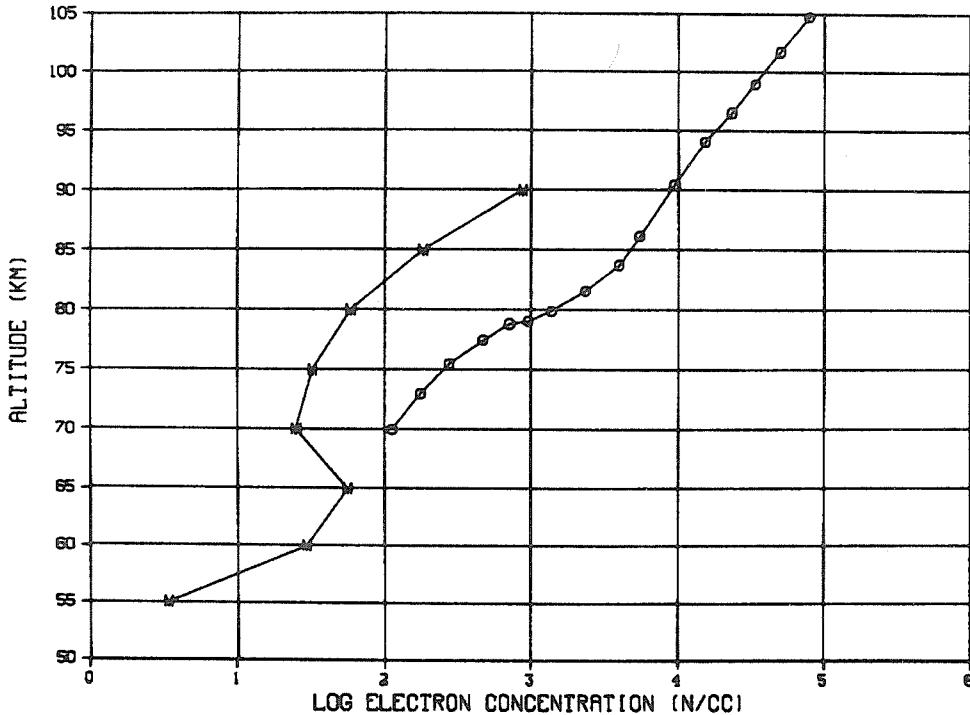


AURORAL ABSORPTION EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 248 66 6 26 1200 45 69.3 16.0 2 1 112 8 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

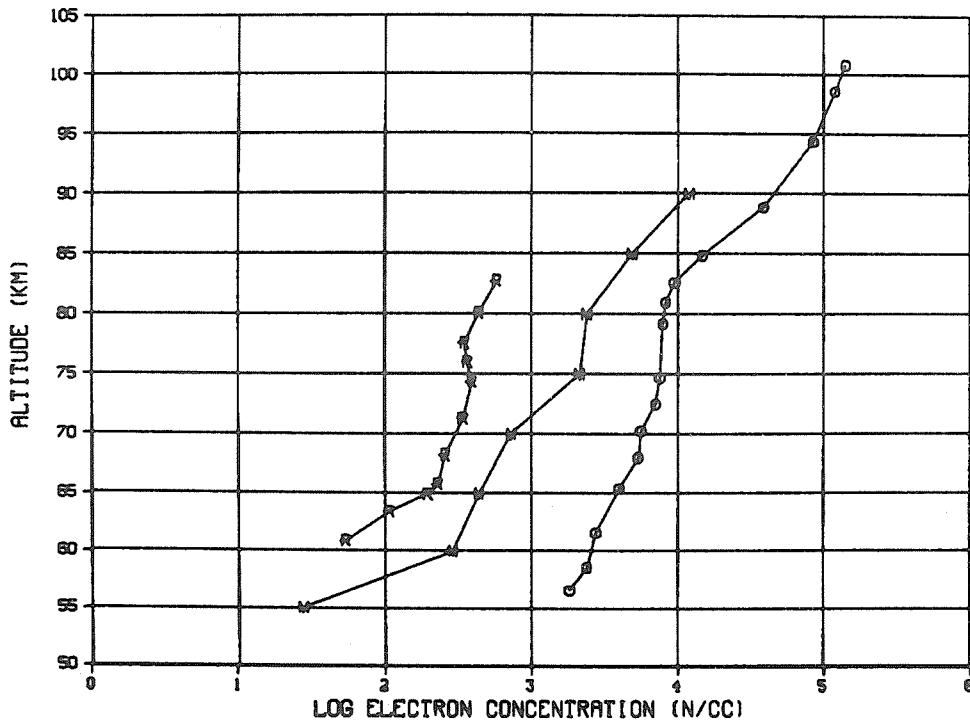


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 272 67 3 15 46 82 69.3 16.0 2 1 75 0 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

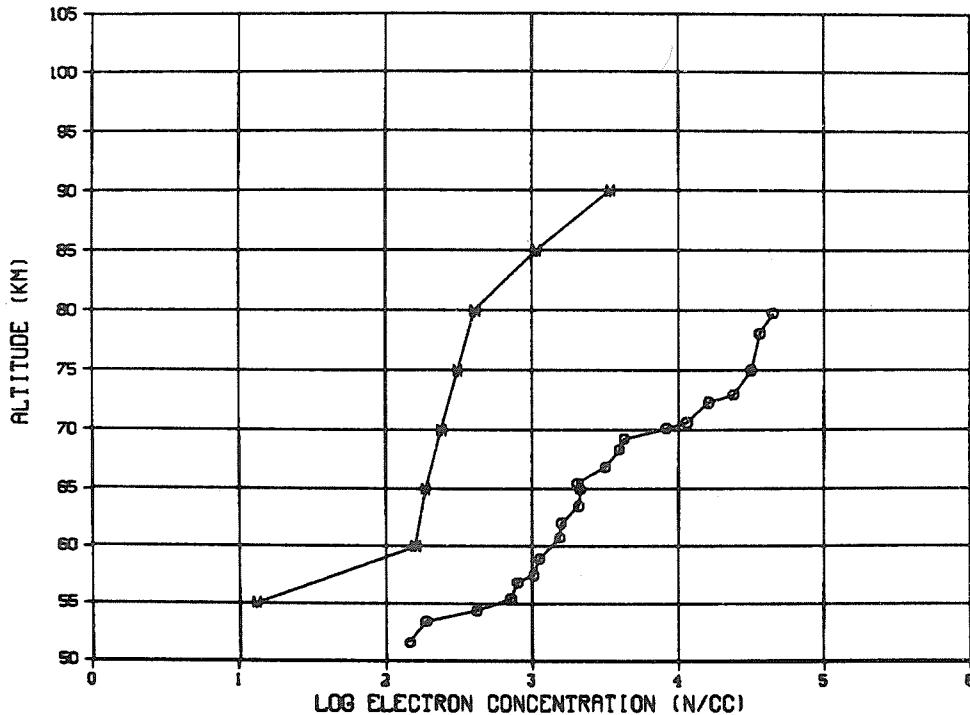


AURORAL ABSORPTION EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)		12	57	7	4	1216	191	58.8	265.8	2	214	9	9
REFERENCE (R)		41	61	6	0	1200	56	45.4	284.1	1	114	9	0
MODEL (M)													

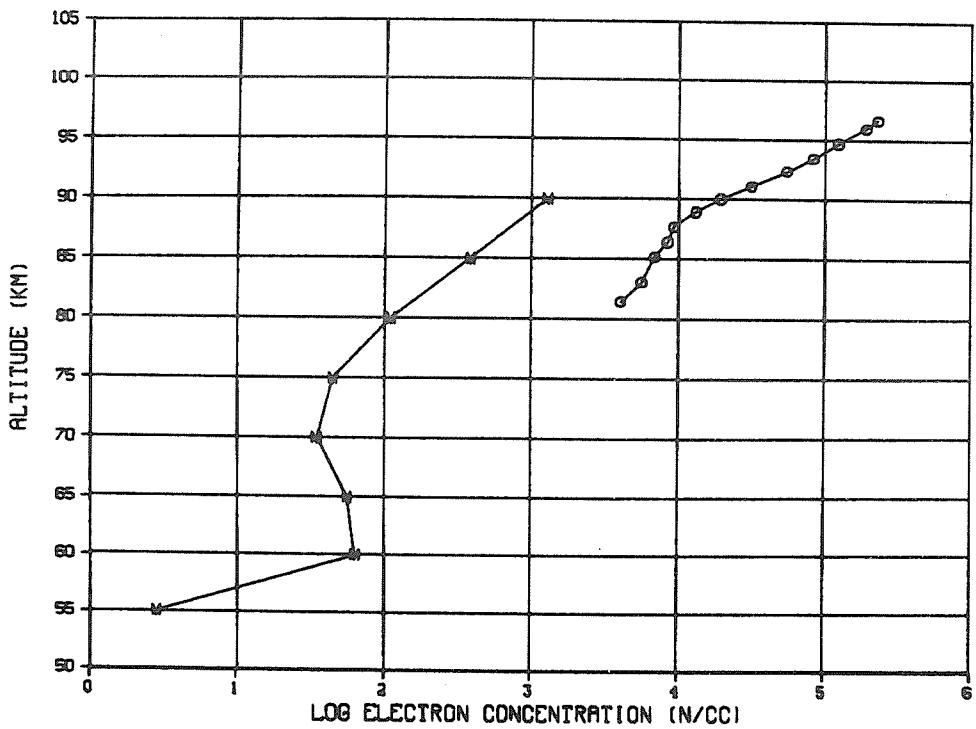


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)		60	62	8	18	809	35	69.3	16.0	2	277	6	9
REFERENCE (R)		0	0	0	0	0	0	0.0	0.0	0	000	0	0
MODEL (M)													

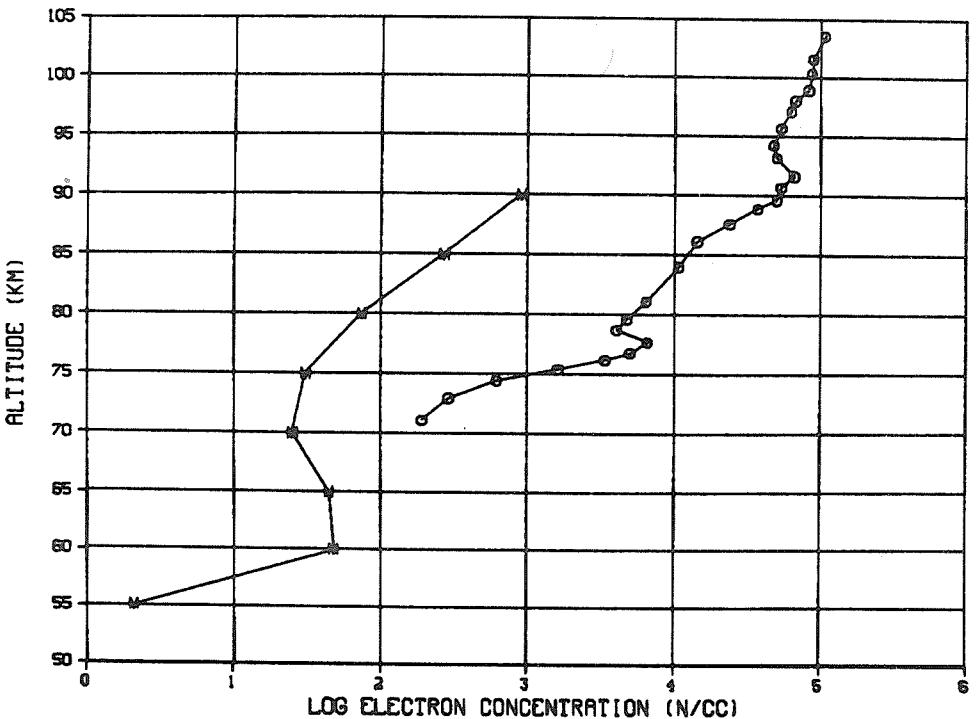


AURORAL ABSORPTION EVENT

CURVE YR MO DY TIME SSNO LAT LONG MTH MAG REF FIG SPC  
 OBSERVED (O) 69 62 12 11 427 30 69.3 16.0 2 277 10 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

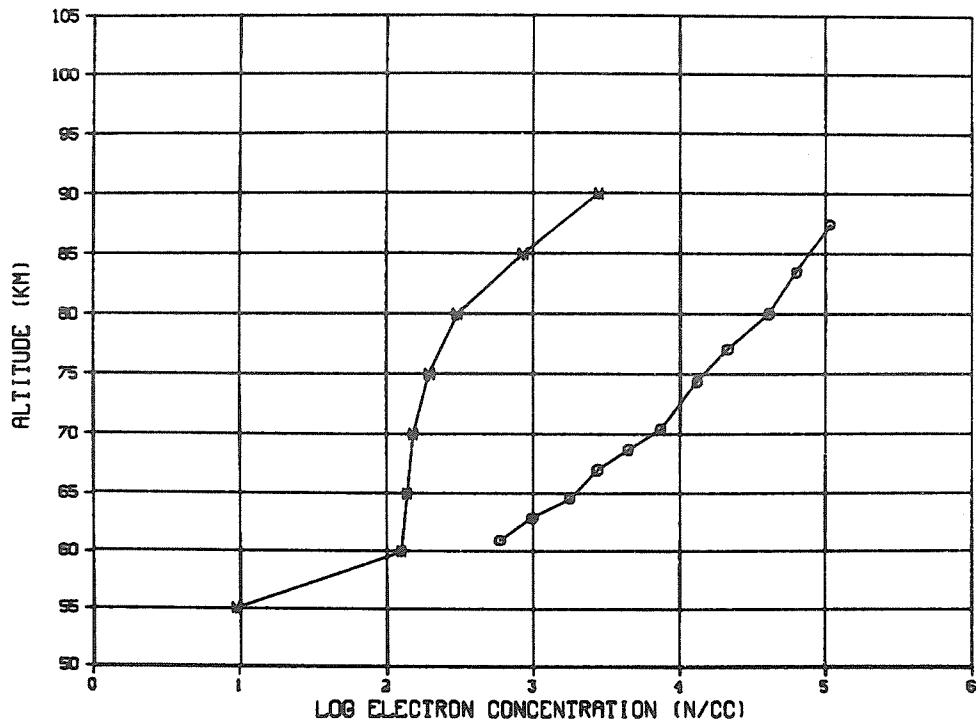


CURVE YR MO DY TIME SSNO LAT LONG MTH MAG REF FIG SPC  
 OBSERVED (O) 70 62 12 14 2152 30 69.3 16.0 2 277 10 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

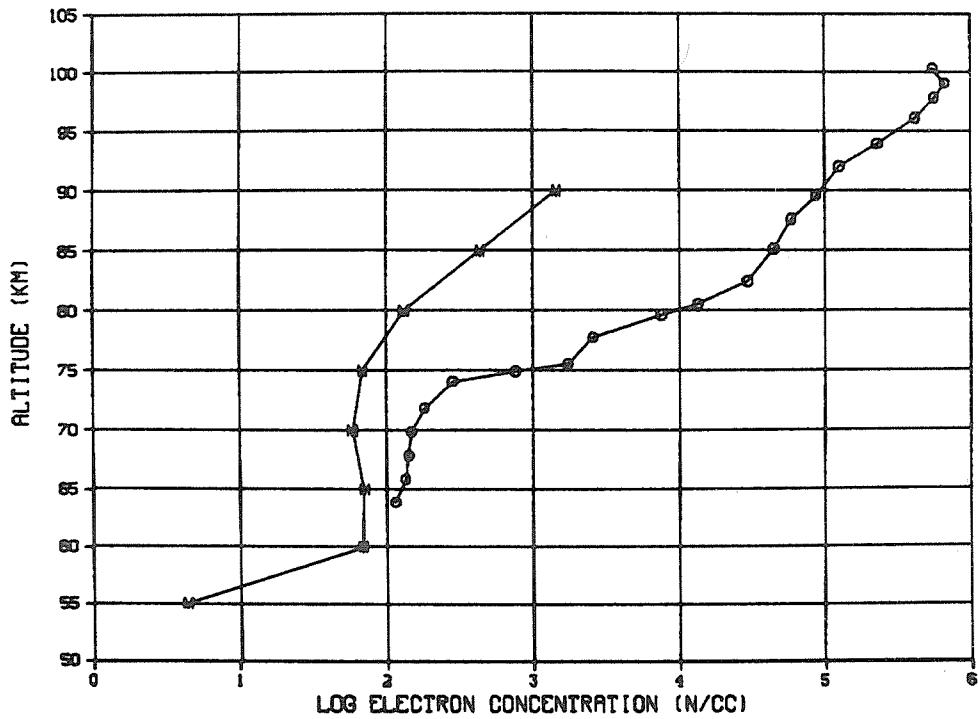


AURORAL ABSORPTION EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 86 63 9 12 720 27 69.3 16.0 2 274 3 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

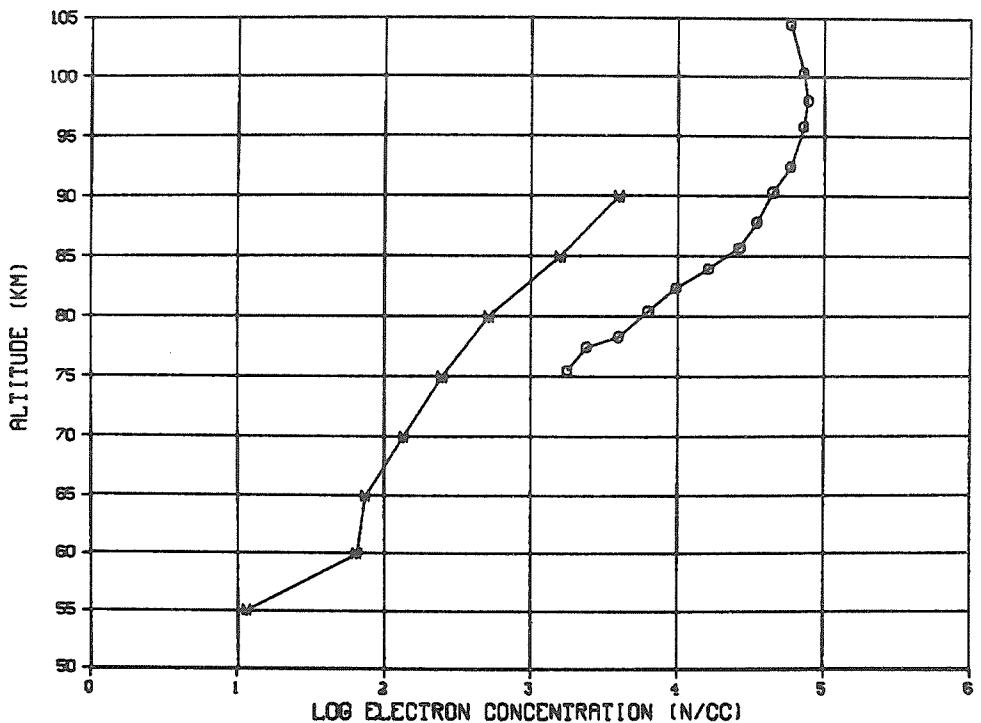


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 99 64 3 12 358 15 69.3 16.0 2 274 3 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

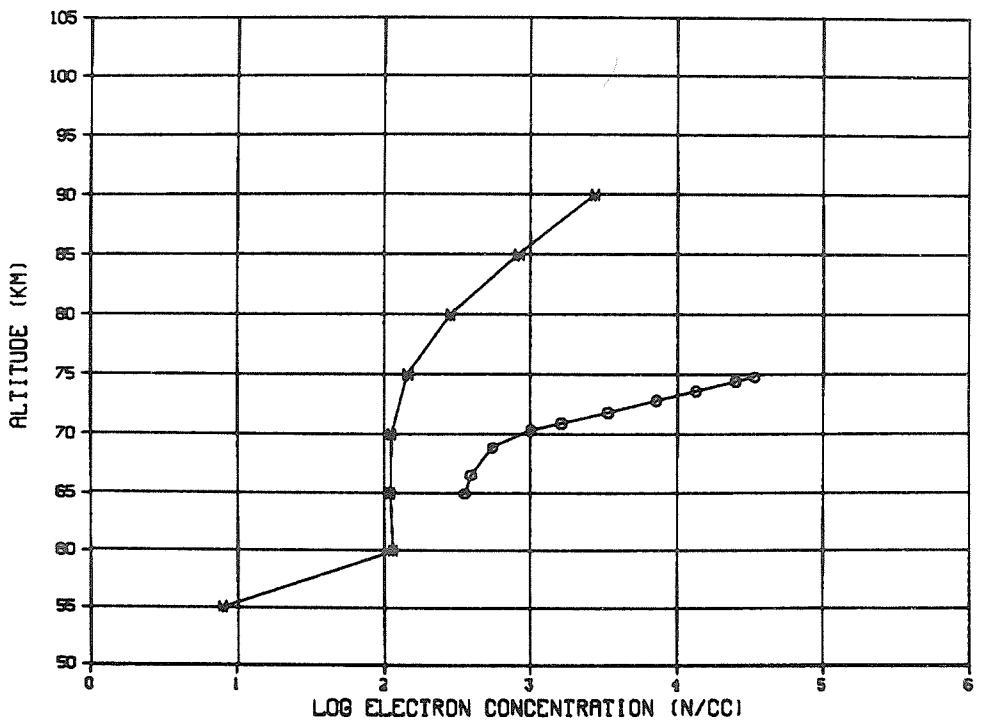


AURORAL ABSORPTION EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 143 64 10 27 1200 10 58.8 265.8 2 2 140 3 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

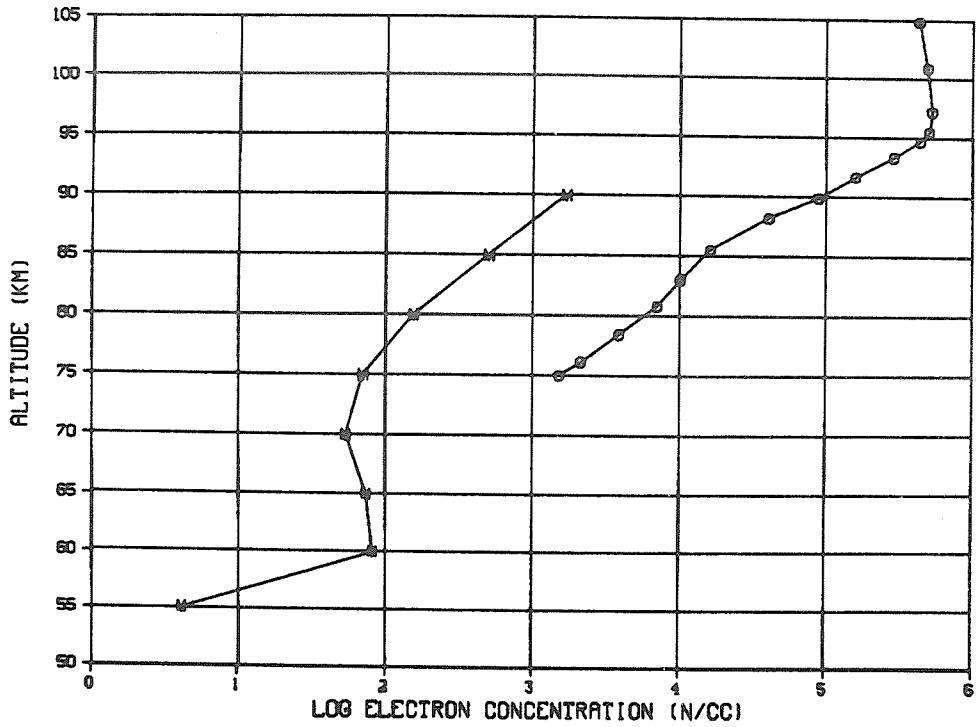


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 168 65 3 21 659 13 69.3 16.0 2 2 275 0 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

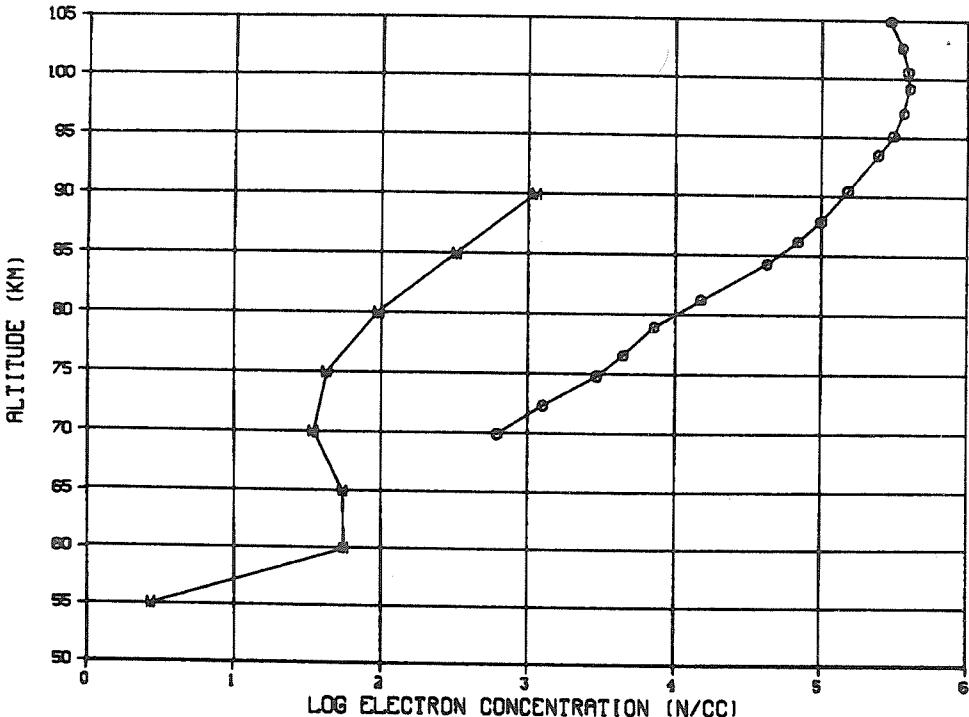


AURORAL ABSORPTION EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 222 66 2 22 1929 31 69.3 16.0 2 275 0 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0.0 0 0 0  
 MODEL (M)

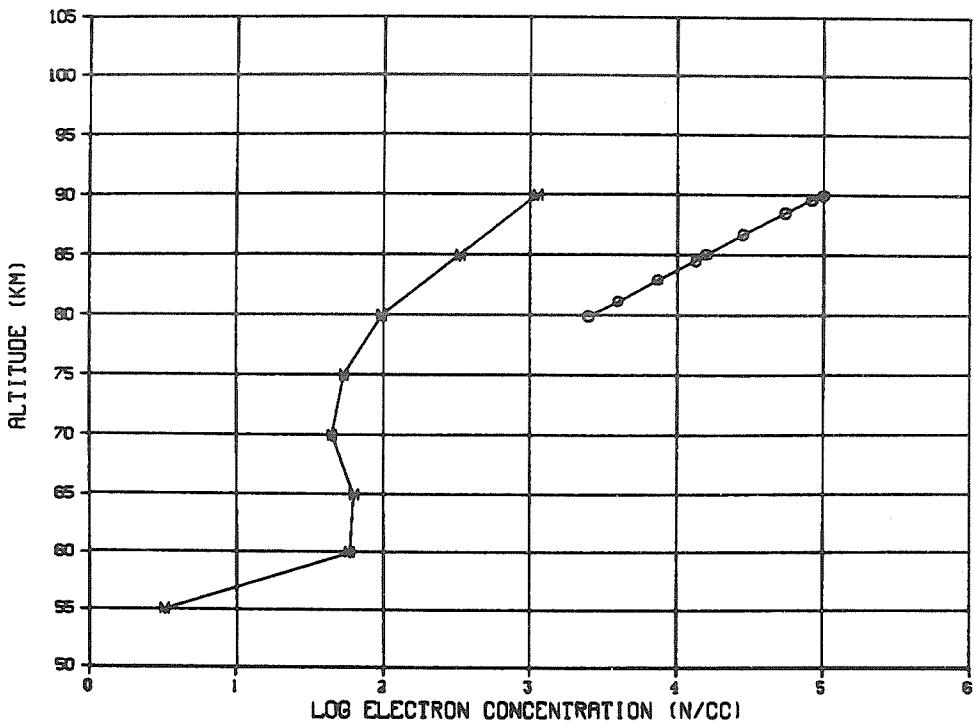


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 223 66 2 24 15 31 69.3 16.0 2 275 0 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0.0 0 0 0  
 MODEL (M)

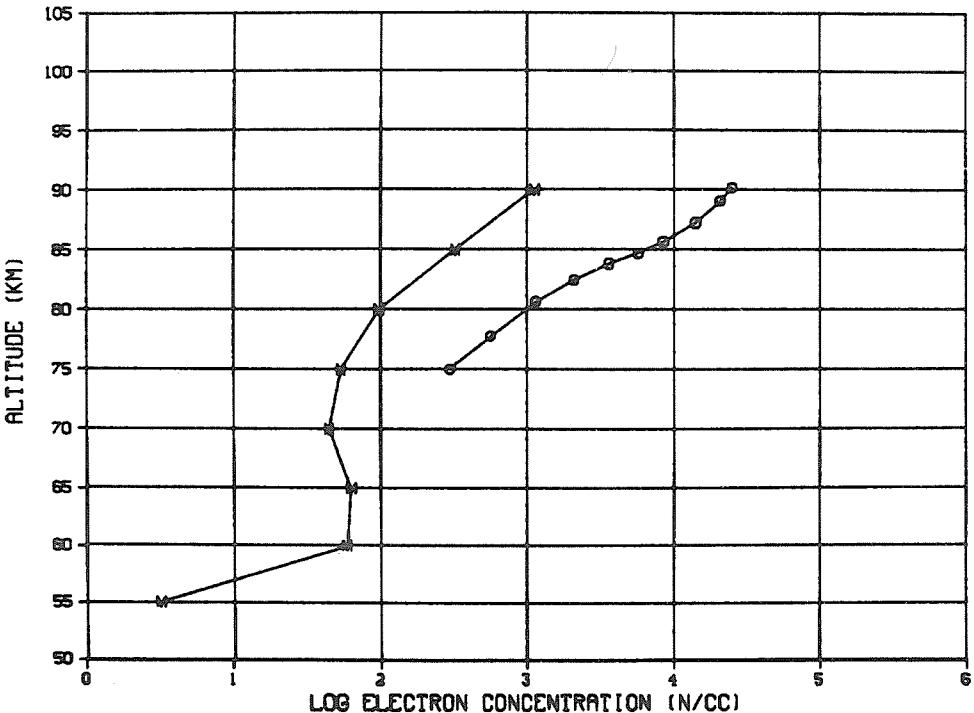


AURORAL ABSORPTION EVENT

CURVE YR MO DY TIME SSNO LAT LONG MTH MAG REF FIG SPC  
 OBSERVED (O) 225 66 3 10 2326 34 69.3 16.0 2 275 0 9  
 REFERENCE (R) O 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

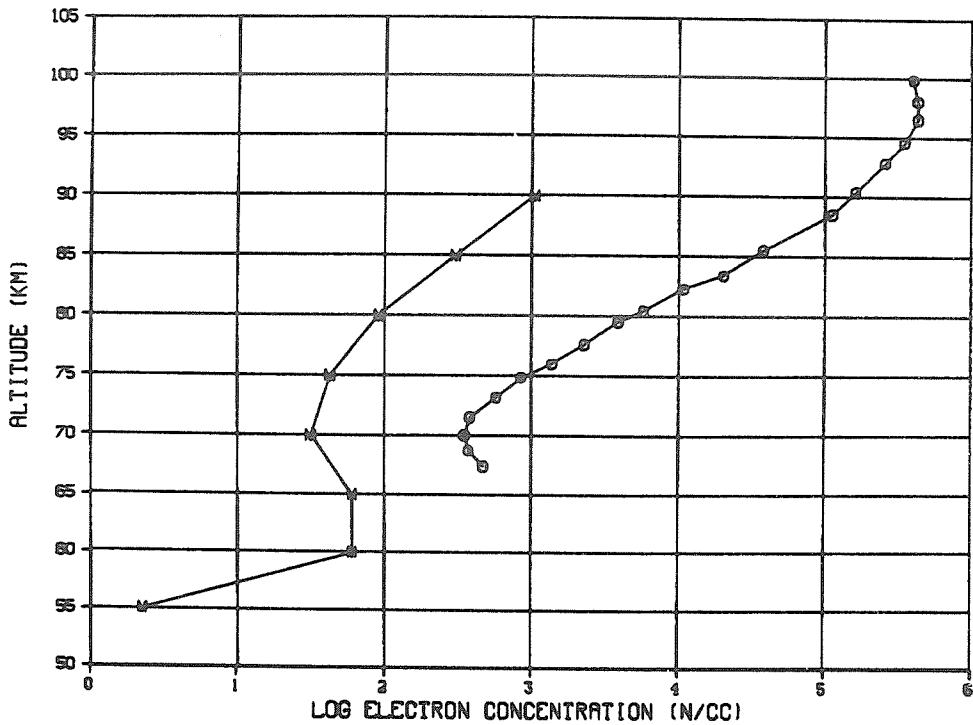


CURVE YR MO DY TIME SSNO LAT LONG MTH MAG REF FIG SPC  
 OBSERVED (O) 224 66 3 9 2320 34 69.3 16.0 2 275 0 9  
 REFERENCE (R) O 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

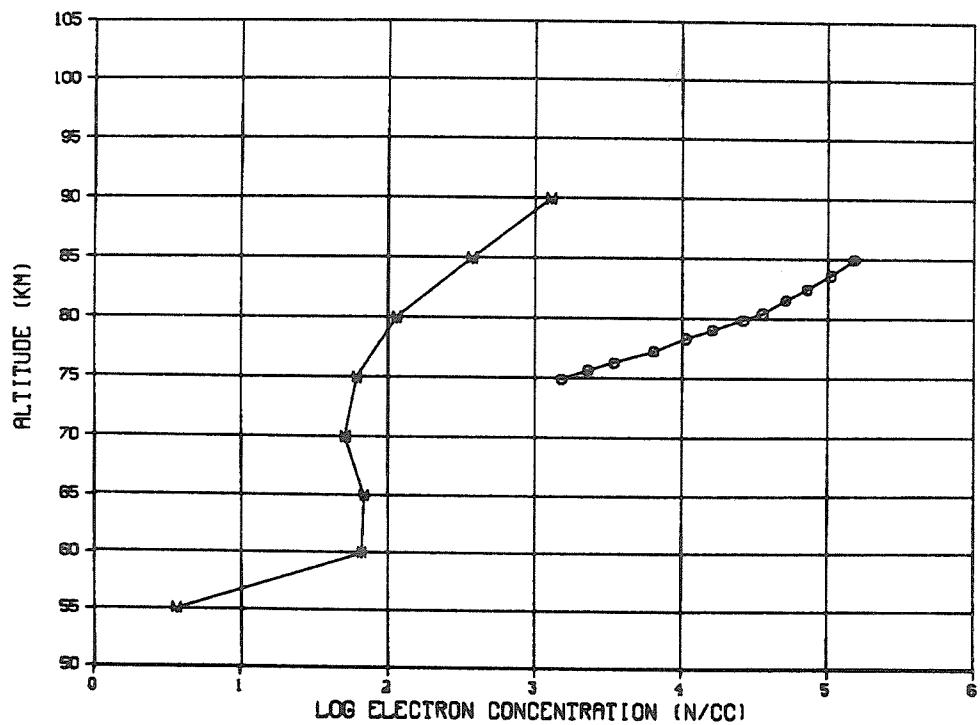


AURORAL ABSORPTION EVENT

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 265 66 11 20 138 70 69.3 16.0 2 275 2 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

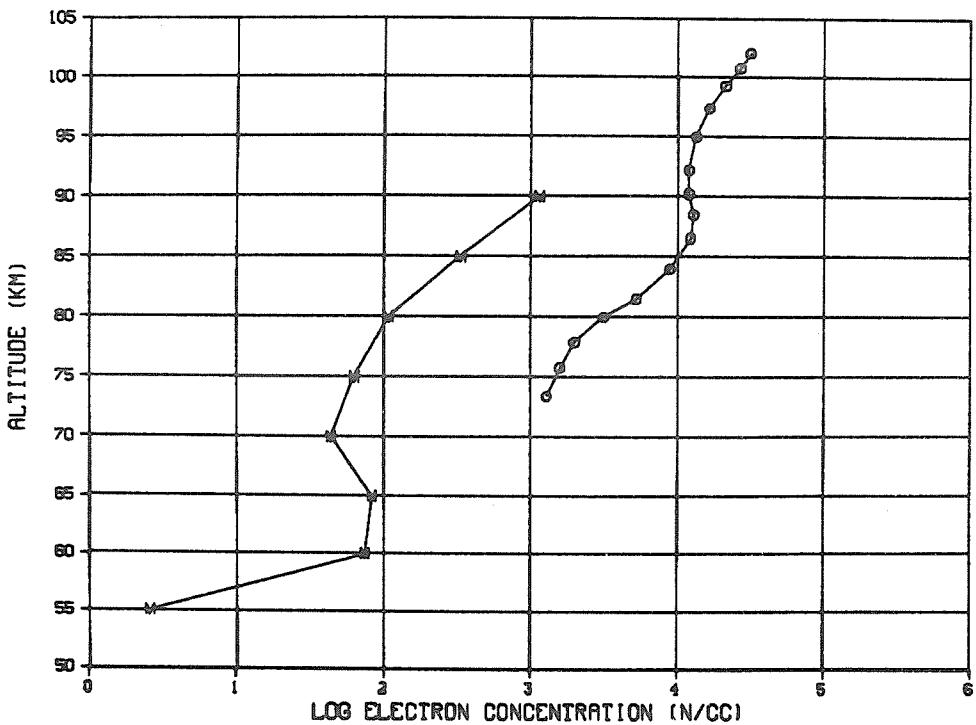


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 226 66 3 22 4 34 69.3 16.0 2 275 0 9  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0 0 0 0  
 MODEL (M)

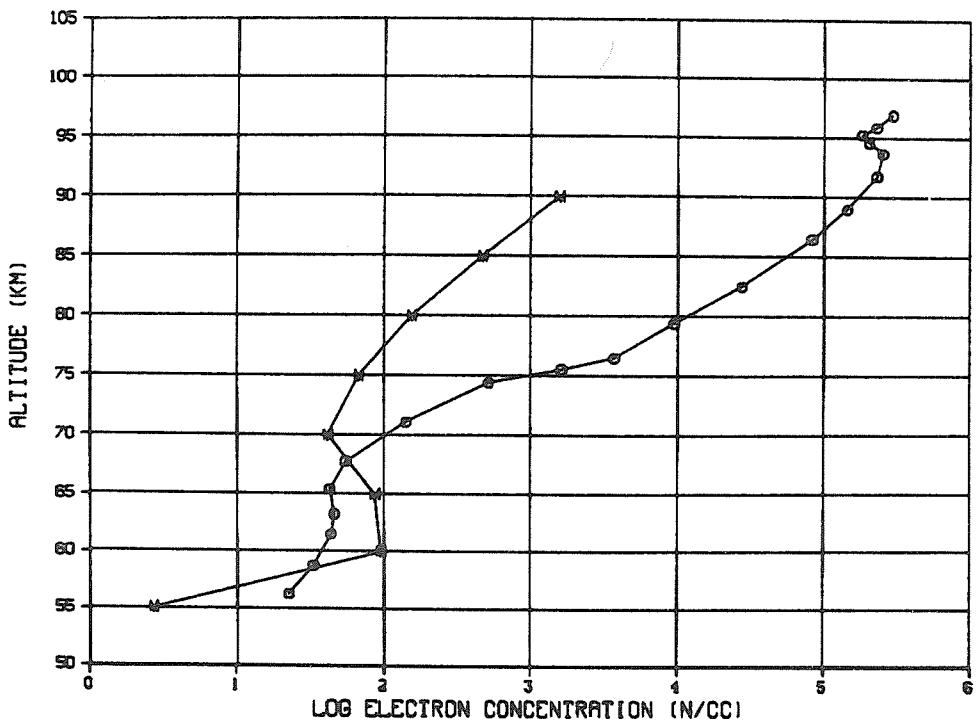


AURORAL ABSORPTION EVENT

CURVE YR MO DY TIME SSNO LAT LONG MTH MAG REF FIG SPC  
 OBSERVED (O) 353 68 10 24 2150 110 67.8 20.4 2 2 47 1 9  
 REFERENCE (R) O 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

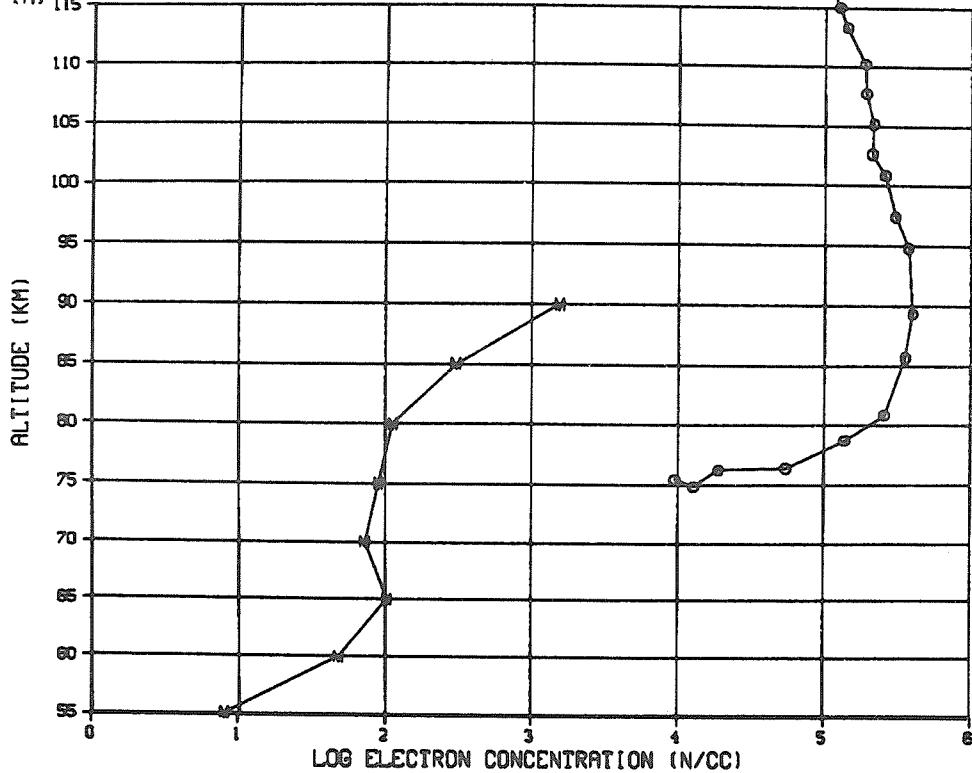


CURVE YR MO DY TIME SSNO LAT LONG MTH MAG REF FIG SPC  
 OBSERVED (O) 362 69 1 18 2024 110 69.3 16.0 2 2 47 1 9  
 REFERENCE (R) O 0 0 0 0 0 0.0 0.0 0 0 0 0 0  
 MODEL (M)

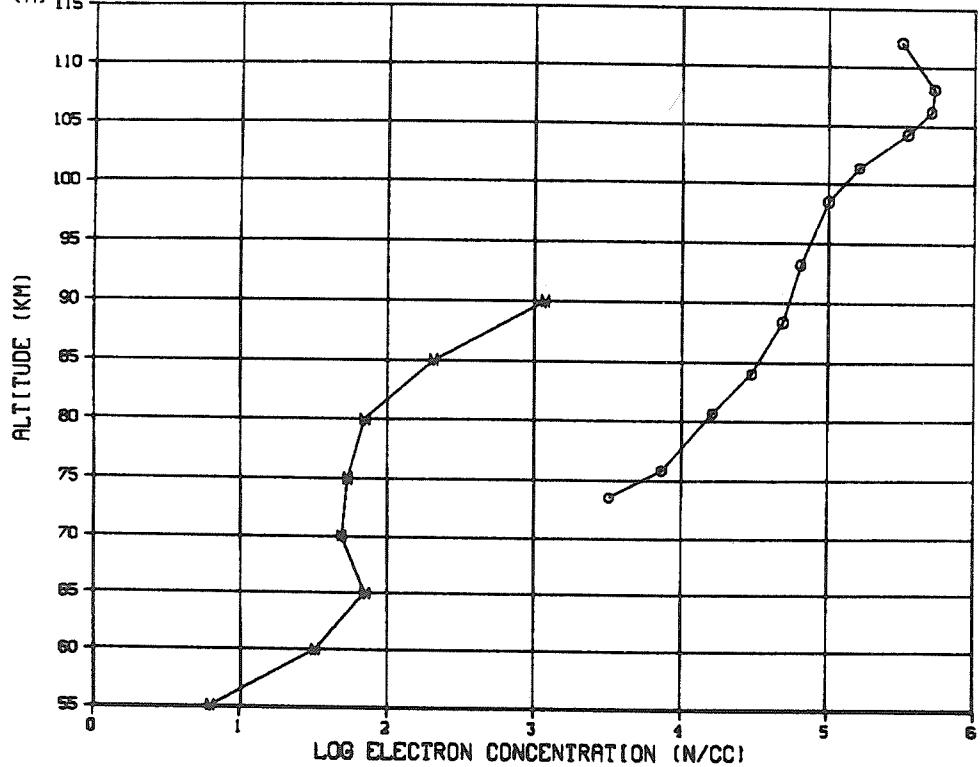


AURORAL ABSORPTION EVENT

CURVE YR MO DY TIME SSNO LAT LONG MTH MAG REF FIG SPC  
 OBSERVED (O) 483 72 8 7 445 66 -69.0 39.0 2 1 100 1 11  
 REFERENCE (R) O O O O O O 0.0 0.0 0.0 0 0 0 0  
 MODEL (M) 115

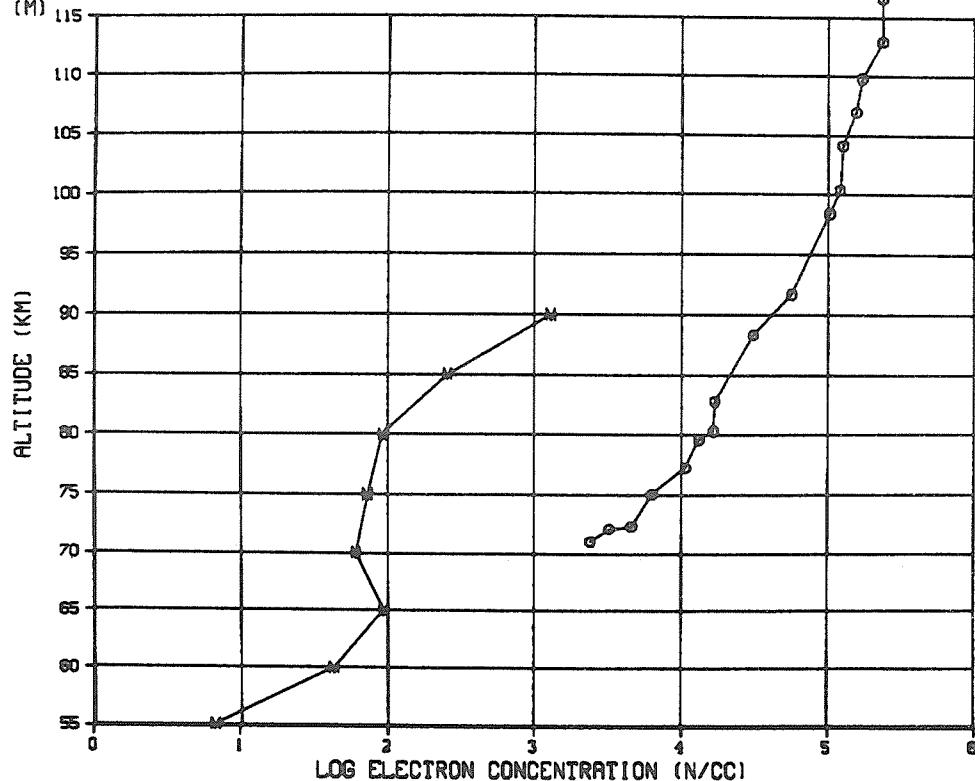


CURVE YR MO DY TIME SSNO LAT LONG MTH MAG REF FIG SPC  
 OBSERVED (O) 488 73 8 23 354 36 -69.0 39.0 2 1 100 7 11  
 REFERENCE (R) O O O O O O 0.0 0.0 0.0 0 0 0 0  
 MODEL (M) 115

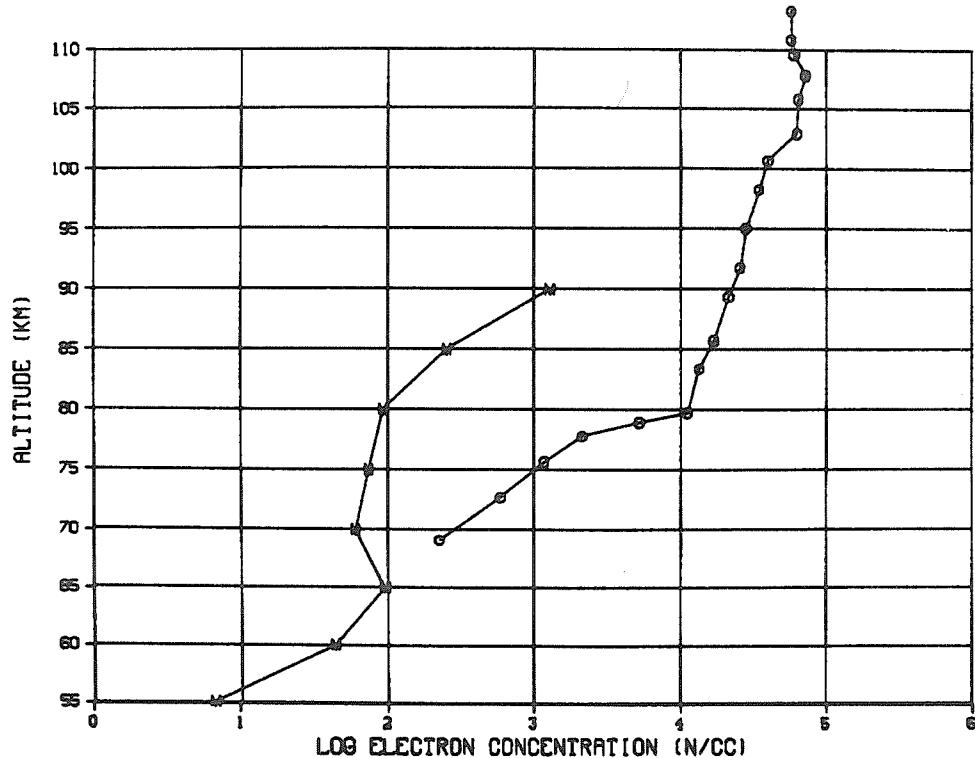


POLAR SUBSTORM

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 482 72 5 14 213 73 -69.0 39.0 2 1 100 1 11  
 REFERENCE (R) O O O O O 0 0.0 0.0 0 0 0 0  
 MODEL (M) 115  
 ALTITUDE (KM)

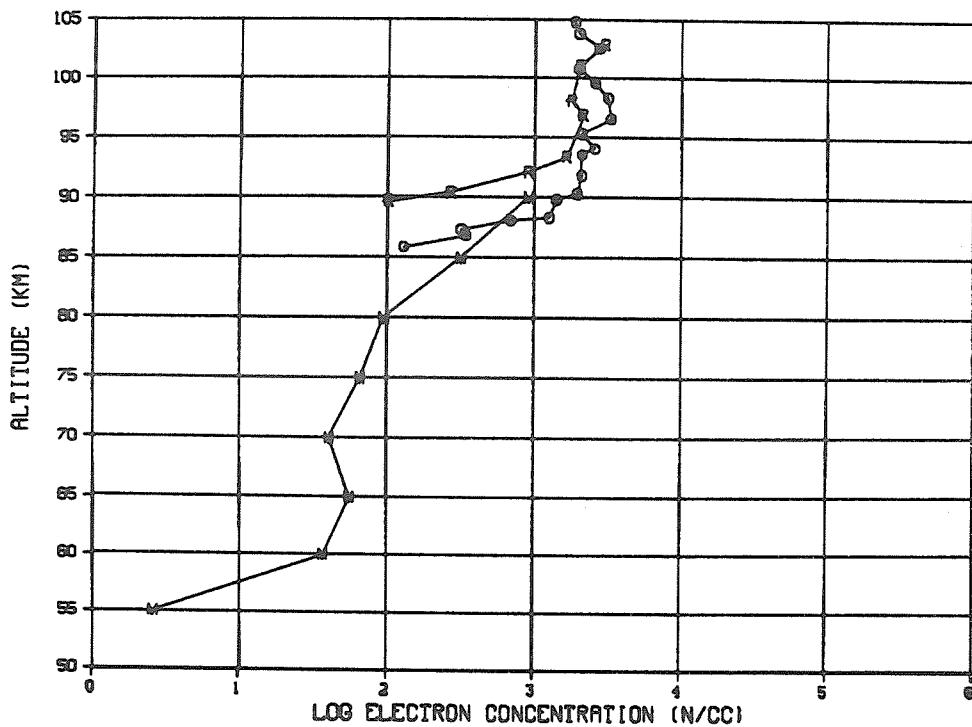


CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 480 72 5 16 202 73 -69.0 39.0 2 1 100 1 11  
 REFERENCE (R) O O O O O 0 0.0 0.0 0 0 0 0  
 MODEL (M) 115  
 ALTITUDE (KM)

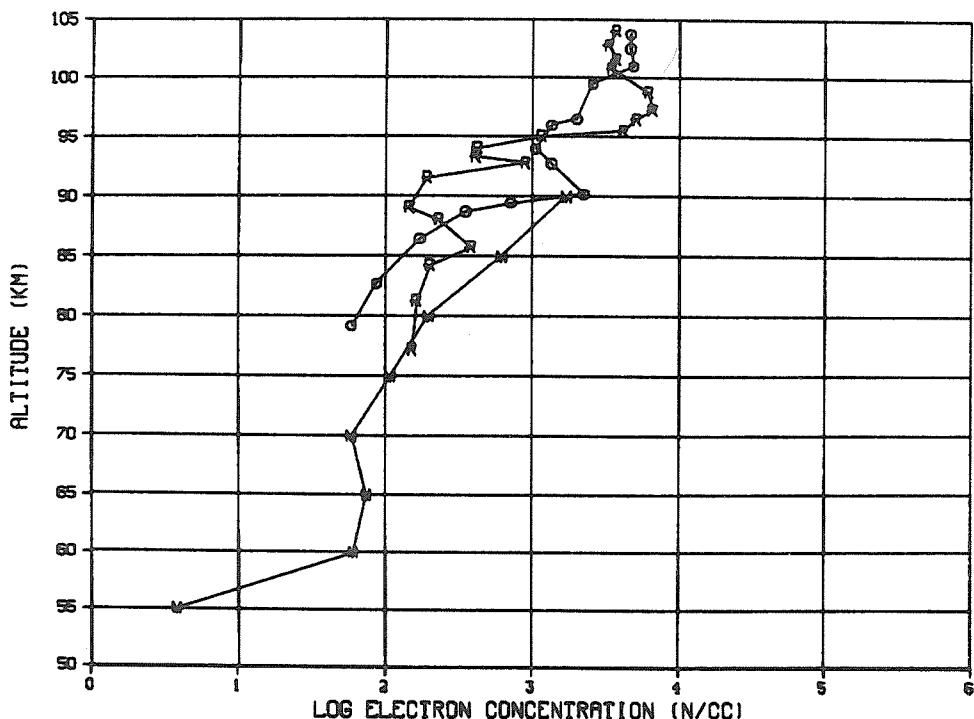


POLAR SUBSTORM

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	995	69	9	30	2241	105	57.2	352.9	2	2	151	3	11
REFERENCE (R)	994	72	8	31	2	65	57.2	352.9	2	1	151	3	0
MODEL (M)													

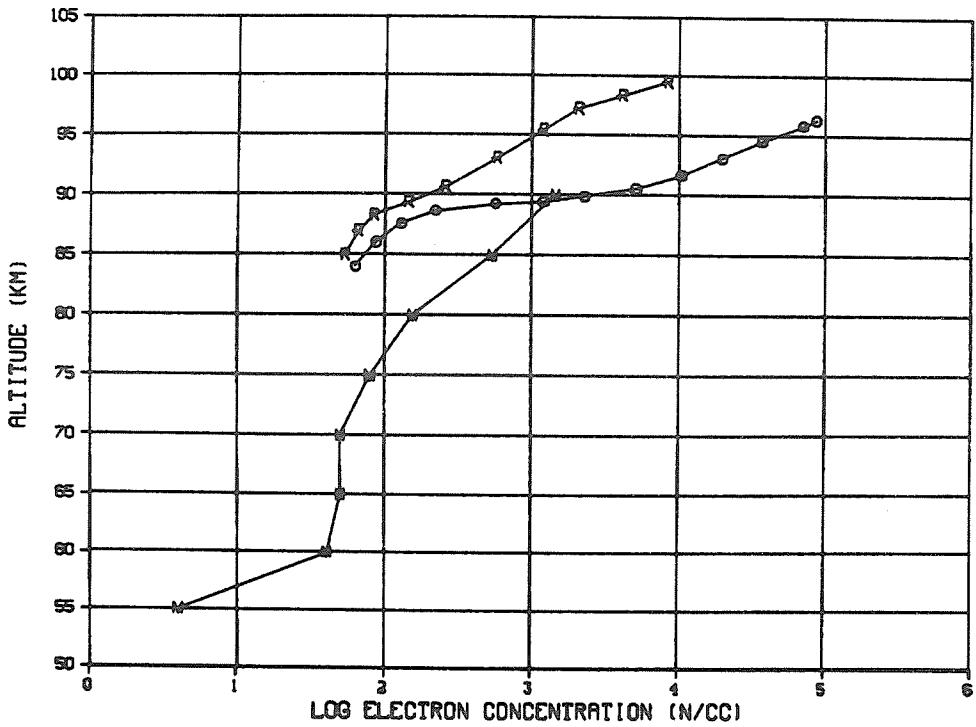


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	996	69	10	1	420	104	57.2	352.9	2	2	151	3	11
REFERENCE (R)	993	72	8	30	2202	65	57.2	352.9	2	1	151	3	0
MODEL (M)													

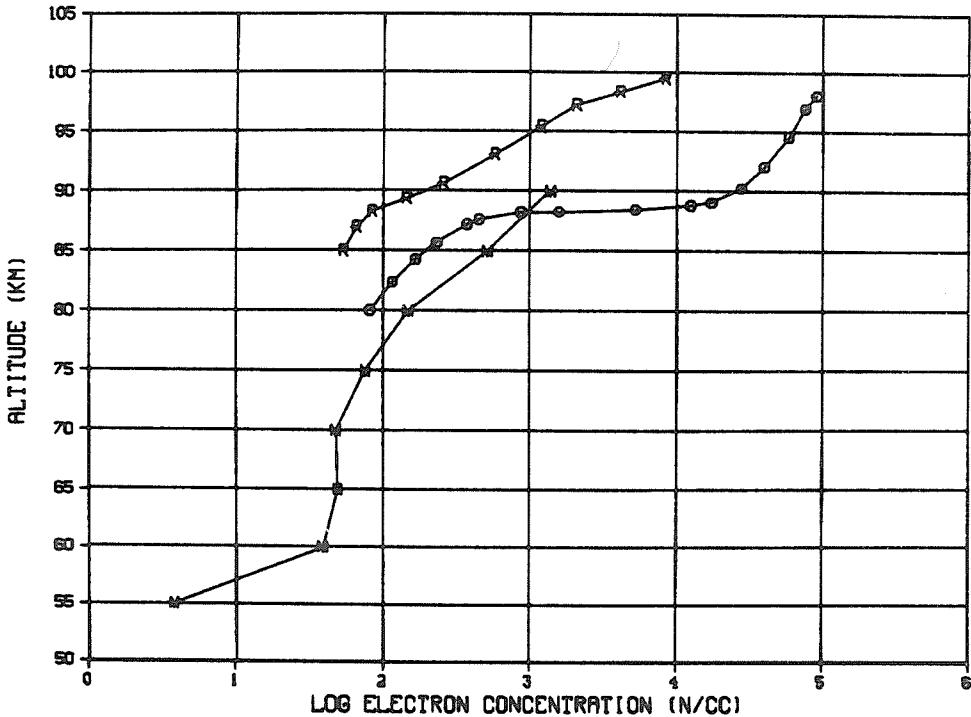


POLAR SUBSTORM

CURVE YR MO DY TIME SSNO LAT LONG MEIH MAG REF FIG SPC  
 OBSERVED (O) 967 73 3 24 2115 44 65.3 212.2 1 2 153 4.3 13  
 REFERENCE (R) 966 73 3 24 2100 44 65.3 212.2 1 2 153 4.3 0  
 MODEL (M)

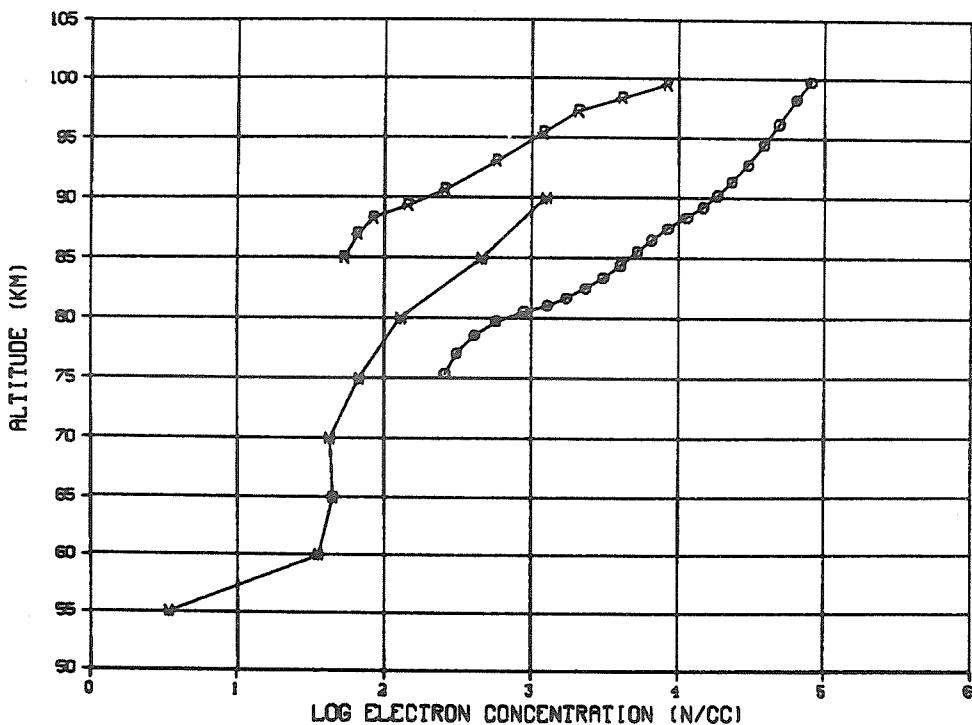


CURVE YR MO DY TIME SSNO LAT LONG MEIH MAG REF FIG SPC  
 OBSERVED (O) 968 73 3 24 2135 44 65.3 212.2 1 2 153 4.3 13  
 REFERENCE (R) 966 73 3 24 2100 44 65.3 212.2 1 2 153 4.3 0  
 MODEL (M)

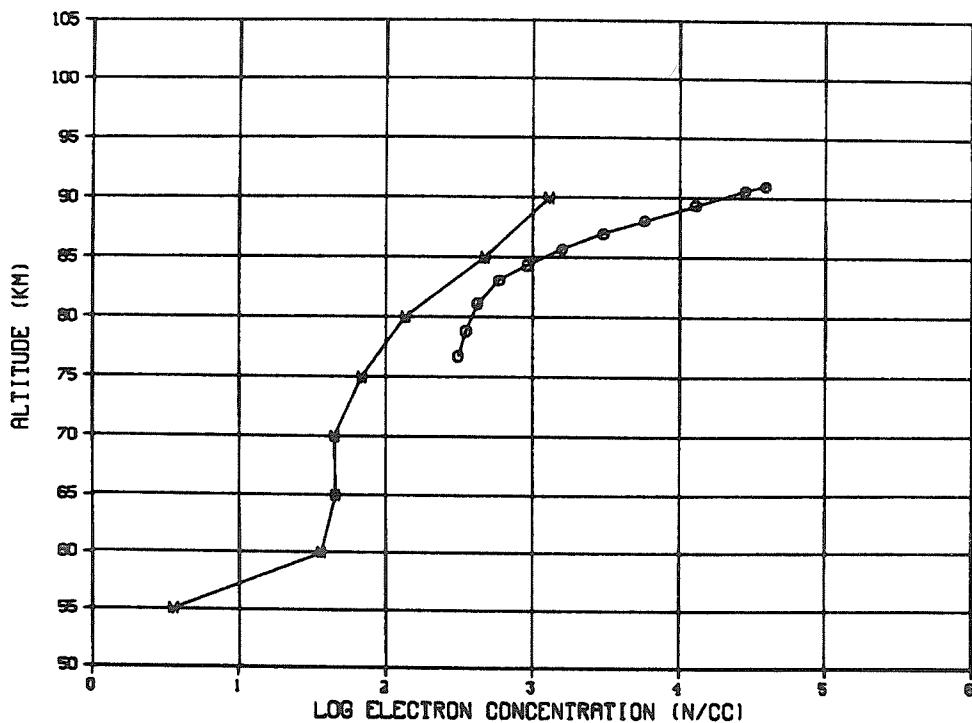


AURORAL ARC CONDITIONS. #966 PRE-ARC; #967 ARC FORMATION; #968 ARC BREAK UP  
 (SEE NEXT PAGE).

CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 969 73 3 24 2250 44 65.3 212.2 1 2 153 4.3 13  
 REFERENCE (R) 966 73 3 24 2100 44 65.3 212.2 1 2 153 4.3 0  
 MODEL (M)



CURVE YR MO DY TIME SSNO LAT LONG METH MAG REF FIG SPC  
 OBSERVED (O) 970 73 3 26 2238 44 65.3 212.2 1 2 153 4.7 13  
 REFERENCE (R) 0 0 0 0 0 0 0.0 0.0 0.0 0 0 0 0  
 MODEL (M)



AURORAL ARC CONDITIONS. #966 PRE-ARC; #969 SUBSEQUENT AURORAL ACTIVITY (SEE PREVIOUS PAGE).

## APPENDIX A

The computer program DISPPLT selects all D-region profiles obtained under specified disturbed conditions, and prepares the data for the plotting program DREGPLT. The input files TAPE5 and TAPE6 are the "header card file," DB1, and the "digitized data file," DB3, described by McNamara [1978]. The input file TAPE7 is the file PRODAT which contains the corresponding values of curve identification number for the disturbed and reference profiles. The program expects the special case parameter to be entered on the keyboard in FORMAT (I2). The output file, TAPE10, should be saved for plotting.

The program listing of DISPPLT below must be changed slightly for magnetically disturbed days to be considered. The statement IF (MAG.NE.1) GO TO 15 must be changed to IF (MAG.NE.2) GO TO 15. The subroutine PROFILE must also be replaced by the version appropriate to magnetically disturbed days, and the first six lines of TAPE7 deleted.

```

PROGRAM DISPPLT(INPUT,OUTPUT,TAPE5,TAPE6,TAPE7,TAPE8,
A TAPE9,TAPE10,TAPE11)
C   PROGRAM TO SELECT "UNUSUAL CONDITION" PROFILES AND THE CORRESPONDING
C   REFERENCE PROFILE (IF ANY) AND CALCULATE STATISTICAL MODEL PROFILE
C...  THIS VERSION MAG QUIET DAYS ONLY
C...  TAPE5 = DB1
C...  TAPE6 = DB3
C...  TAPE7 = TABLE OF CORRESPONDING REFERENCE PROFILES
C...  TAPE8 = OUTPUT FILE ..... HEADER CARDS
C...  TAPE11 = OUTPUT FILE ..... HEADER CARDS FOR REFERENCE PROFILES
C...  TAPE9 = OUTPUT FILE ..... DIGITIZED DATA
C...  TAPE10 = OUTPUT ARRANGED IN MORE SUITABLE ORDER
DIMENSION NUM(100),IYL(100),IML(100),IDL(100),LHL(100),LML(100),
A ISL(100),FFL(100),FWL(100),DEN(8),HT(8),H(200),
A FLN(200),OBS(8),IK(100),IR(100),IRFL(100),IKRL(100)
DIMENSION ADEN(8),AHT(8)
DIMENSION BLANKS(20)
DATA BLANKS / 20*4H
C
C   READ IN THE REFERENCE PROFILES CORRESPONDING TO EACH "UNUSUAL PROFILE"
READ(7,400) (IK(L),IR(L),L=1,64)
400 FORMAT(26I3)
C
C   HEIGHTS AT WHICH DENSITIES ARE TO BE FOUND
DO 3 I=1,8
3   HT(I)=90.-5.* (I-1)
C
C*** WHAT SPECIAL CASE PARAMETER IS TO BE CONSIDERED?????????
5   READ 10, ISPECL
     IF(ISPECL.EQ.0) STOP
     PRINT 200,ISPECL
200 FORMAT(//1X,*SPECIAL CASE PARAMETER =*,I3)
10   FORMAT(I2)
     REWIND 5
     REWIND 6
     REWIND 7
     REWIND 8
     REWIND 9
     REWIND 11
C
C   READ IN THE HEADER CARD FILE TO FIND ALL REQUIRED PROFILES
L=0
15   READ(5,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
A MAG,KOL,IREF,IFIG,ISPEC
100  FORMAT(I5,4I3,I2,I4,2F6.1,2I2,I3,I4,A5,2I3)
     IF(KURVE.EQ.9999) GO TO 25
C---- MAGNETICALLY QUIET DAYS ONLY
     IF(MAG.NE.1) GO TO 15
     IF(ISPEC.EQ.ISPECL) GO TO 20
     GO TO 15
20   L=L+1
     IF(L.LE.100) GO TO 22
     PRINT 23
23   FORMAT(* TOO MANY CASES*)
     STOP
22   NUM(L)=KURVE

```

APPENDIX A (Continued)

```

C      FIND CORRESPONDING REFERENCE PROFILE
DO 21 I=1,64
II=I
IF(KURVE.EQ.IK(I)) GO TO 24
21    CONTINUE
GO TO 19
24    IKR=IR(II)
IKRL(L)=IKR
19    CONTINUE
IYL(L)=IY
IML(L)=IM
IDL(L)=ID
LHL(L)=LH
LML(L)=LM
ISL(L)=ISSNO
FFL(L)=FLAT
FWL(L)=360.-FLON
IRFL(L)=IREF
C      WRITE OUT THE HEADER CARD INFORMATION
WRITE(8,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
A MAG,KOL,IREF,IFIG,ISPEC,IKR
PRINT 100, KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
A MAG,KOL,IREF,IFIG,ISPEC,IKR
GO TO 15
C      ALL DATA READ IN
25    REWIND 5
LL=L
KK=9999
WRITE(8,100) KK
C      WRITE OUT HEADER CARDS FOR REFERENCE PROFILES
C      READ (5,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
115   A MAG,KOL,IREF,IFIG,ISPEC
IF(KURVE.EQ.9999) GO TO 125
DO 124 J=1,LL
IF(KURVE.NE.IKRL(J)) GO TO 124
WRITE(11,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
A MAG,KOL,IREF,IFIG,ISPEC
PRINT 100, KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
A MAG,KOL,IREF,IFIG,ISPEC
GO TO 115
124   CONTINUE
GO TO 115
125   KK=9999
WRITE(11,100) KK
REWIND 5
C      FOR EACH REQUIRED PROFILE, CALCULATE STATISTICAL MODEL AND
C      FIND REFERENCE PROFILE
PRINT 210, LL
210   FORMAT(/1X,*THERE ARE *,I3,* SUCH PROFILES*)
IF(LL.EQ.0) GO TO 5
C      READ IN THE DIGITIZED PROFILES ONE BY ONE
40    READ(6,110) KURVE
110   FORMAT(I4)
IF(KURVE.EQ.9999) GO TO 74
J1=-5
60    J1=J1+6
J2=J1+5
READ(6,120) (FLN(J),H(J),J=J1,J2)
120   FORMAT(12F6.2)
IF(H(J2).NE.0.) GO TO 60
C      SEE IF THIS CURVE IS A REQUIRED SPECIAL CASE
DO 71 L=1,LL
IF(KURVE.NE.NUM(L)) GO TO 71
C      CURVE IS REQUIRED .. WRITE IT OUT
WRITE(9,110) KURVE
WRITE(9,120) (FLN(J),H(J),J=1,J2)
GO TO 40
71    CONTINUE

```

APPENDIX A (Continued)

```

C SEE IF CURVE IS A REQUIRED REFERENCE CURVE
DO 73 L=1,LL
IF(KURVE.NE.IKRL(L)) GO TO 73
C CURVE IS REQUIRED
WRITE(9,110) KURVE
WRITE(9,120) (FLN(J),H(J),J=1,J2)
GO TO 40
73 CONTINUE
GO TO 40
C CALCULATE STATISTICAL MODEL PROFILE
74 CONTINUE
DO 75 L=1,LL
ABSLAT=ABS(FFL(L))
FLON=360.-FWL(L)
CALL PROFILE(IYL(L),IML(L),IDL(L),LHL(L),LML(L),ISL(L),
A ABSLAT,FWL(L),DEN)
C::: ARRANGE THE POINTS IN ASCENDING HEIGHT ORDER :::::
DO 77 I=1,8
J=8-I+1
ADEN(I)=DEN(J)
77 AHT(I)=HT(J)
C WRITE OUT THE STATISTICAL PROFILE
NUML=1000+NUM(L)
WRITE(9,110) NUML
WRITE(9,120) (ADEN(I),AHT(I),I=1,8)
C PRINT 300,IYL(L),IML(L),IDL(L),LHL(L),LML(L),ISL(L),
C A FFL(L),FLON
75 CONTINUE
300 FORMAT(///* 19*,I2,3I3,I2,I5,2F6.1)
C
C PRINT 105,NUM(L),HT
C PRINT 150,DEN
C PRINT 151,OBS
105 FORMAT(1X,*PROFILE NUMBER = *,I4,/1X,* HEIGHTS *,8F6.1)
150 FORMAT(1X,*CALCULATED*,8F6.1)
151 FORMAT(1X,* OBSERVED *,8F6.1)
C
REWIND 8
REWIND 9
REWIND 11
C WRITE OUT THE DATA IN A MORE SUITABLE FORM
78 READ(8,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
A MAG,KOL,IREF,IFIG,ISPEC,IKR
IF(KURVE.EQ.9999) GO TO 99
79 READ(9,110) KKV
J1=-5
80 J1=J1+6
J2=J1+5
READ(9,120) (FLN(J),H(J),J=J1,J2)
IF(H(J2).NE.0.) GO TO 80
C SEE IF THIS IS THE REQUIRED DISTURBED PROFILE
IF(KKV.NE.KURVE) GO TO 79
WRITE(10,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
A MAG,KOL,IREF,IFIG,ISPEC,IKR
C FIND HEADER CARD FOR REFERENCE PROFILE AND WRITE IT OUT
93 READ(11,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
A MAG,KOL,IREF,IFIG,ISPEC
IF(KURVE.EQ.9999) GO TO 94
IF(KURVE.NE.IKR) GO TO 93
WRITE(10,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
A MAG,KOL,IREF,IFIG,ISPEC
REWIND 11
GO TO 95
94 REWIND 11
WRITE(10,432) (BLANKS(II),II=1,20)
432 FORMAT(20A4)
95 CONTINUE
WRITE(10,110) KKV
WRITE(10,120) (FLN(J),H(J),J=1,J2)
REWIND 9

```

APPENDIX A (Continued)

```

C      LOOK FOR REFERENCE PROFILE
81     READ(9,110) KKW
        IF(EOF(9).EQ.0.) GO TO 87
C      NO REFERENCE PROFILE
        DO 86 I=1,12
          FLN(I)=0.
86     H(I)=0.
KZ=0
        WRITE(10,110) KZ
        WRITE(10,120) (FLN(I),H(I),I=1,6)
        REWIND 9
        GO TO 88
87     CONTINUE
        J1=-5
82     J1=J1+6
        J2=J1+5
        READ(9,120) (FLN(J),H(J),J=J1,J2)
        IF(H(J2).NE.0.) GO TO 82
        IF(KKW.NE.IKR) GO TO 81
        WRITE(10,110) KKW
        WRITE(10,120) (FLN(J),H(J),J=1,J2)
C      LOOK FOR MODEL PROFILE .... NO NEED TO REWIND
88     CONTINUE
        KKX=1000+KKV
83     READ(9,110) KKK
        J1=-5
84     J1=J1+6
        J2=J1+5
        READ(9,120) (FLN(J),H(J),J=J1,J2)
        IF(H(J2).NE.0.) GO TO 84
        IF(KKK.NE.KKX) GO TO 83
        WRITE(10,110) KKX
        WRITE(10,120) (FLN(J),H(J),J=1,J2)
C
        REWIND 9
        GO TO 78
C
99     CONTINUE
C
C      RETURN FOR NEXT SPECIAL CASE PARAMETER
        GO TO 5
        END
        SUBROUTINE PROFILE (IY,IM,ID,LH,LM,ISSNO,FLAT,WLON,DEN)
C      S/R TO CALCULATE A D-REGION PROFILE USING THE STATISTICAL MODEL
C      WITH COEFFICIENTS A,B,C,D,E
C..... MAGNETICALLY QUIET DAYS ONLY.   DENSITY INCREASES BY A FACTOR
C      OF ABOUT TWO ON DISTURBED DAYS
        DIMENSION A(8),B(8),C(8),D(8),E(8),F(8),T(8),DEN(8)
C      A = CONSTANT TERM    90(5)55 KM
        DATA A / 3.21,2.32,1.87,1.64,1.49,1.25,.81,.82 /
C      B = COS KI TERM
        DATA B / .80,.86,1.03,1.00,.86,.57,.66,.77 /
C      C = GEOMAGNETIC LATITUDE TERM
        DATA C / 0.,.23,.16,.09,.17,.58,.78,0. /
C      D = SUNSPOT TERM
        DATA D / 0.,.13,.20,.25,.13,.26,.26,0. /
C      E = SEASONAL TERM
        DATA E / .15,.16,.17,0.,-.05,0.,.12,0. /
C      RESIDUAL STANDARD DEVIATION
        DATA F / .53,.50,.46,.39,.33,.32,.40,.47 /
C
        PI=3.141592654
C      PREPARE TO CHANGE TO GEOMAGNETIC LATITUDE AT WLON DEGREES (WEST)
        DEGRAD=PI/180.
        THETGM=11.5*DEGRAD
        COSGM=COS(THETGM)
        SINGM=SIN(THETGM)
        PHIGM=291.*DEGRAD
C

```

APPENDIX A (Continued)

```

C   CONVERT TO GEOMAGNETIC LATITUDE
COLAT=(90.-FLAT)*DEGRAD
ALON=WLON*DEGRAD
COSA=COS(COLAT)*COSGM+SIN(COLAT)*SINGM*COS(ALON-PHIGM)
GEOML=90.-ACOS(COSA)/DEGRAD
TLAT=SIN(2.*GEOML*PI/180.)
ALAT=0.1+0.9*(SIN(GEOML*PI/180.))**4
FMON=IM
FMON=(FMON-0.5)/12.*2.*PI
FMON=COS(FMON)
IF(FLAT.LT.0.) FMON=-FMON
SEASON=FMON
IID=ID
IF(ID.EQ.0) IID=15
CALL COSKI(IY,IM,IID,LH,LM,FLAT,WLON,COSX)
DO 20 I=1,8
IHT=90-(I-1)*5
T(1)=A(I)
T(2)=COSX*B(I)
XLAT=TLAT
IF(I.GE.5) XLAT=ALAT
T(3)=XLAT*C(I)
T(4)=ISSNO*.01*D(I)
T(5)=SEASON*E(I)
T(6)=F(I)
ED=0.
DO 15 J=1,5
15 ED=ED+T(J)
DEN(I)=ED
20 CONTINUE
RETURN
END
SUBROUTINE COSKI(LLY,LMON,LDAY,LH,LM,DLAT,DLON,COSX)
C   MODIFIED VERSION OF NEWBURN SMITH'S COS(SOLAR ZENITH ANGLE) S/R
C.... IT IS ASSUMED THAT THE GIVEN LOCAL TIME WAS MEASURED AT THE
C NEAREST STANDARD MERIDIAN I.E. THE NEAREST MULTIPLE OF 15 DEGREES
C.... LY = LOCAL YEAR    LAST TWO DIGITS ONLY
C   LMON = LOCAL MONTH
C   LDAY = LOCAL DAY
C   LH = LOCAL HOUR
C   LM = LOCAL MINUTE
C   DLAT = NORTHERN LATITUDE IN DEGREES
C   DLON = WEST LONGITUDE IN DEGREES
C   DIMENSION NDO(12),NDL(12)
C   DATA DTR / 0.01745329 /
C   DAY NUMBERS FOR ORDINARY AND LEAP YEARS
C   DATA NDO,NDL / 1,32,60,91,121,152,182,213,244,274,305,335,
A 1,32,61,92,122,153,183,214,245,275,306,336/
C   AMPLITUDES OF FOURIER EXPANSION COEFFICIENTS    1955 EPOCH
C   DATA P1,P2,P3,P4,P6 /
A 0.017203534,0.034407068,0.051610602,0.068814136,0.103221204 /
IF(MOD(LY,4).EQ.0) LD=NDL(LMON)+LDAY-1
IF(MOD(LY,4).NE.0) LD=NDO(LMON)+LDAY-1
LY=LLY-60
MER=INT((DLON+7.5)/15.)*15.
C   FIND TIME OF THE EQUINOX FOR THAT YEAR
IF(LY) 7,7,9
7  IL=INT((3.1-LY)/4.)
GO TO 11
9  IL=-INT((LY+.1)/4.)
11 DT=-0.7819+0.24225*LY+IL
TD=LD+(LH+LM/60.+MER/15.)/24.
TE=TD-DT
C   DECLINATION
DCL=23.256*SIN(P1*(TE-82.242))+.381*SIN(P2*(TE-44.855))+.167*SIN
1(P3*(TE-23.355))-0.013*SIN(P4*(TE+11.97))+.011*SIN(P6*(TE-10.41))
2+.339137
DC=DCL*DTR
TF=TE-.5

```

APPENDIX A (Continued)

```
C THE EQUATION OF TIME
EQT=-7.38*SIN(P1*(TF-4.))-9.87*SIN(P2*(TF+9.))+.27*SIN(P3*(TF-53.
A))- .2*COS(P4*(TF-17.))
ET=EQT*DTR/4.
FA=DLAT*DTR
FB=DLON*DTR
FC=MER*DTR
PHO=FC-FB+ET
T=LH+LM/60.
PHI=.26179939*(T-12.)+PHO
A=SIN(FA)*SIN(DC)
B=COS(FA)*COS(DC)
COSX=A+B*COS(PHI)
RETURN
END
```

Listing of File PRODAT

```
246000850234409417410417414417944943809808971972947948541540542540543540 64 63
324323920000945946406405407405518517922 54548583579583580583581583221220450451
455451288287268220545544 48 49992991527 0158160159160357354358354938250933 0
932 0807 0 42 41282 0248 0269 0272 0484 0485 0486 0487 0559 0560 0
488000480000481000482000483000562000 16000 17000 18000 19000 20000 21000
DELETE FIRST 6 LINES IF DOING MAG DISTURBED DAYS
523524275000356354368000369000360000381923387923375925376925377000378000379000
383000380000384000386000388000389000365000366000382000390000385000804000805000
806000353000362000265000150151143000144000 86000 99000100000 60000 69000 70000
222000223000224000225000226000567 41168000 12 41253000254000995994996993970000
967966968966969966
```

APPENDIX A (Continued)

Listing of Subroutine PROFILE for Magnetically Disturbed Days

```

SUBROUTINE PROFILE (IY,IM, ID,LH,LM,ISSNO,FLAT,WLON,DEN)
C S/R TO CALCULATE A D-REGION PROFILE USING THE STATISTICAL MODEL.
C WITH COEFFICIENTS A,B,C,D,E,F
C MAGNETICALLY DISTURBED DAYS ONLY
C DIMENSION A(8),B(8),C(8),D(8),E(8),F(8),T(8),DEN(8),G(8)
C A = CONSTANT TERM      90(5)55 KM
C DATA A / 3.12,2.30,1.88,1.66,1.49,1.25,0.81,0.82 /
C B = COS KI TERM
C DATA B / .82,.86,.98,.95,.84,.58,.68,.77 /
C C = GEOMAGNETIC LATITUDE TERM
C DATA C / 0.,.24,.15,.09,.18,.57,.78,0. /
C D = SUNSPOT TERM
C DATA D / .15,.15,.22,.26,.13,.26,.25,0. /
C E = SEASONAL TERM
C DATA E / .17,.18,.18,0.,-0.06,0.,.12,0. /
C MAGNETIC TERM
C DATA F / .17,.34,.31,.32,.32,.21,.45,0. /
C RESIDUAL STANDARD DEVIATION
C DATA G / .53,.51,.47,.40,.33,.32,.40,.47 /
C
C PI=3.141592654
C PREPARE TO CHANGE TO GEOMAGNETIC LATITUDE AT WLON DEGREES (WEST)
C DEGRAD=PI/180.
C THETGM=11.5*DEGRAD
C COSGM=COS(THETGM)
C SINGM=SIN(THETGM)
C PHIGM=291.*DEGRAD
C
C CONVERT TO GEOMAGNETIC LATITUDE
COLAT=(90.-FLAT)*DEGRAD
ALON=WLON*DEGRAD
COSA=COS(COLAT)*COSGM+SIN(COLAT)*SINGM*COS(ALON-PHIGM)
GEOML=90.-ACOS(COSA)/DEGRAD
TLAT=SIN(2.*GEOML*PI/180.)
ALAT=0.1+0.9*(SIN(GEOML*PI/180.))**4
FMON=IM
FMON=(FMON-0.5)/12.*2.*PI
FMON=COS(FMON)
IF(FLAT.LT.0.) FMON=-FMON
SEASON=FMON
IID=ID
IF(ID.EQ.0) IID=15
CALL COSKI(IY,IM,IID,LH,LM,FLAT,WLON,COSX)
DO 20 I=1,8
IHT=90-(I-1)*5
T(1)=A(I)
T(2)=COSX*B(I)
XLAT=TLAT
IF(I.GE.5) XLAT=ALAT
T(3)=XLAT*C(I)
T(4)=ISSNO*.01*D(I)
T(5)=SEASON*E(I)
T(6)=F(I)
ED=0.
DO 15 J=1,6
15 ED=ED+T(J)
DEN(I)=ED
20 CONTINUE
RETURN
END

```

## APPENDIX B

The program DREGPLT plots the D-region profiles as indicated in the diagrams. The version listed below is suitable for a height range of 50 to 105 km. Slight changes are necessary for profiles containing points outside this range.

### Listing of DREGPLT

```

C-----THIS PROGRAM PLOTS ELECTRON DENSITY VERSUS HEIGHT
C-----FOR D REGION PROFILES.
C-----MARCUS ERTLE PROGRAMMER, JUN. 1978.
      PROGRAM DREGPLT(INPUT,OUTPUT,TAPE1=INPUT,TAPE2=OUTPUT,
XTAPE3)
      COMMON A(2,6),X(100),Y(100),INPT(1)
C     IEND=1
C     IEND=0
      CALL TEKTRN(460)
2     CALL BGNPL(IEND)
      KPT=0
      NH=0
      IC=0
      IO=0
      M=0
      N=0
      CALL TITLE(" $", -100, "LOG ELECTRON CONCENTRATION (N/CC) $",
X100, "ALTITUDE (KM) $", 100, 8., 6.)
      CALL YINTAX
      CALL XINTAX
      CALL YAXANG(0.0)
      CALL GRAF(0,1,6,50,5,105)
C     CALL GRAF(0,1,6,35,5,90)
C     CALL GRAF(0,1,6,55,5,115)
      CALL GRID(1,1)
4     CALL CURVENO(IDIST,IYR,IMO,IDX,ITIME,ISUN,STLAT,
XSTLONG,IMETH,IMAG,ICOL,IREF,UFIG,ISC,JREF,
XJDIST,JYR,JMO,JDY,JTIME,JSUN,SJSLAT,
XSJSLONG,JMETH,JMAG,JCOL,JJREF,UJFIG,JSC,JJJREF,N,NH,MODE,IO,IC)
      IF(N.EQ.2) 40,5
5     IF(NH.EQ.0) 20,6
6     CALL MARKER(MODE)
      CALL EPOINTS(N)
      CALL FILLUP(M,KPT,N)
      IF(X(M).EQ.0.00) 15,4
15    CALL CURVE(X,Y,KPT,1)
      KPT=0
      M=0
      IO=0
      IF(IC.NE.3) GOTO 4
      CALL MESSAG("CURVE YR MO DY TIME SSNO LAT LONG",39,0.,7.25)
      CALL MESSAG("METH MAG REF FIG SPC",23,"ABUT","ABUT")
      CALL MESSAG("OBSERVED (O) ",14,-1.5,7.)
      CALL INTNO(IDIST,"ABUT","ABUT")
      CALL INTNO(IYR,.75,"ABUT")
      CALL INTNO(IMO,1.1,"ABUT")
      CALL INTNO(IDY,1.45,"ABUT")
      CALL INTNO(ITIME,1.8,"ABUT")
      CALL INTNO(ISUN,2.6,"ABUT")
      CALL REALNO(STLAT,1,3.25,"ABUT")
      CALL REALNO(STLONG,1,4.,"ABUT")
      CALL INTNO(IMETH,5.2,"ABUT")
      CALL INTNO(IMAG,5.65,"ABUT")
      CALL INTNO(IREF,5.85,"ABUT")
      CALL MESSAG(UFIG,5,6.5,"ABUT")
      CALL INTNO(ISC,7.25,"ABUT")
      CALL MESSAG("REFERENCE (R) ",14,-1.5,6.75)
      CALL INTNO(JDIST,.2,"ABUT")
      CALL INTNO(JYR,.75,"ABUT")
      CALL INTNO(JMO,1.1,"ABUT")
      CALL INTNO(JDY,1.45,"ABUT")
      CALL INTNO(JTIME,1.8,"ABUT")

```

APPENDIX B (Continued)

```

CALL INTNO(JSUN,2.6,"ABUT")
CALL REALNO(SJTLAT,1,3.25,"ABUT")
CALL REALNO(SJTLONG,1,4.,"ABUT")
CALL INTNO(JMETH,5.2,"ABUT")
CALL INTNO(JMAG,5.65,"ABUT")
CALL INTNO(JJREF,5.85,"ABUT")
CALL MESSAG(UJFIG,5,6.5,"ABUT")
CALL INTNO(JSC,7.25,"ABUT")
CALL MESSAG("MODEL (M)      ",14,-1.5,6.5)
20 CALL ENDPL(IEND)
C IEND=IEND+1
GOTO 2
40 CALL ENDPL(IEND)
CALL DONEPL
END
SUBROUTINE CURVENO(IDIST,IYR,IMO,IDY,ITIME,ISUN,STLAT,
XSTLONG,IMETH,IMAG,ICOL,IREF,UFIG,ISC,JREF,
XJDIST,JYR,JMO,JDY,JTIME,JSUN,SJTLAT,
XSJTLONG,JMETH,JMAG,JCOL,JJREF,UJFIG,JSC,JJJREF,N,NH,MODE,I0,IC)
COMMON A(2,6),X(100),Y(100),INPT(1)
C PRINT 103,NH
103 FORMAT(I3)
IF(NH.GE.1) GOTO 3
1 READ(3,100) IDIST,IYR,IMO,IDY,ITIME,ISUN,STLAT,STLONG,
XIMETH,IMAG,ICOL,IREF,UFIG,ISC,JREF
IF.EOF(3)) 2,300
300 READ(3,100) JDIST,JYR,JMO,JDY,JTIME,JSUN,SJTLAT,SJTLONG,
XJMETH,JMAG,JCOL,JJREF,UJFIG,JSC,JJJREF
IF.EOF(3)) 2,3
102 FORMAT(I3,I3)
2 N=2
RETURN
3 NH=NH+1
IF(I0.EQ.1) 17,4
4 READ(3,101) IMODEL,ICURV
C PRINT 101,IMODEL,ICURV
IF.EOF(3)) 2,5
5 I0=1
IC=IC+1
IF(ICURV.EQ.IDIST) 6,7
6 IF(IMODEL.EQ.1) 8,9
7 IF(ICURV.EQ.JREF) 12,17
8 MODE=-1
GOTO 17
9 MODE=1
GOTO 17
12 MODE=-2
17 RETURN
100 FORMAT(2X,I3,3I3,I5,I4,2F6.1,2I2,I3,I4,A5,I3,I3)
101 FORMAT(I1,I3)
END
SUBROUTINE EPOINTS(N)
COMMON A(2,6),X(100),Y(100),INPT(1)
READ(3,100)((A(I,J),I=1,2),J=1,6)
IF.EOF(3)) 5,10
5 N=2
10 RETURN
100 FORMAT(2X,6(F4.2,F6.2,2X))
END
SUBROUTINE FILLUP(M,KPT,N)
COMMON A(2,6),X(100),Y(100),INPT(1)
10 DO 15 K=1,6
M=M+1
X(M)=A(1,K)
Y(M)=A(2,K)
IF(X(M).EQ.0.00) 12,14
12 RETURN
14 KPT=KPT+1

```

APPENDIX B (Continued)

```
15    CONTINUE
      RETURN
      END
      SUBROUTINE PICTUR(I)
      DIMENSION X1(5),Y1(5),X2(9),Y2(9)
C
      DATA X1/- .035,- .035,0.,.035,.035/
      DATA Y1/- .05,.05,- .05,.05,- .05/
C
      DATA X2/- .035,- .035,.020,.035,.035,
      X.020,- .05,0.,.035/
      DATA Y2/- .05,.05,.05,.04,.04,0.,
      X0.,0.,- .05/
C
      GOTO (1,2), I
1     CALL PICTRC(X1,Y1,5)
      RETURN
2     CALL PICTRC(X2,Y2,9)
      RETURN
      END
```

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